STUDIES ON FORMULATION OF NON - FAT DAIRY WHITENER BASED ON UF BUTTERMILK

THESIS SUBMITTED TO THE
NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL
(DEEMED UNIVERSITY)
IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE AWARD OF THE DEGREE OF

MASTER OF TECHNOLOGY
IN
DAIRYING
(DAIRY TECHNOLOGY)

BY
HARICHARAN MAHTO

DIVISION OF DAIRY TECHNOLOGY
NATIONAL DAIRY RESEARCH INSTITUTE
(I. C. A. R.)
KARNAL - 132001 (HARYANA), INDIA

2005

Regn. No. 2030305

DEDICATED TO MY PARENTS, WIFE
&
DAUGHTER NIKITA

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Approved by

EXTERNAL EXAMINER

(Vijay Kumar Gupta)
MAJOR ADVISER & CHAIRMAN
(GUIDE)

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CERTIFICATE

This is to certify that the thesis entitled, **"STUDIES ON FORMULATION OF NON-FAT DAIRY WHITENER BASED ON UF BUTTERMILK"** submitted by **Mr. HARICHARAN MAHTO** towards the partial fulfillment of the award of the degree of **MASTER OF TECHNOLOGY** in **DAIRYING (DAIRY TECHNOLOGY)** of NATIONAL DAIRY RESEARCH INSTITUTE (*DEEMED UNIVERSITY*), Karnal (Haryana), India, is a bonafide research work carried out by him under my supervision, and no part of the thesis has been submitted for any other degree or diploma.

Dated: June 6, 2005

(Vijay Kumar Gupta)
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CONTENTS

LIST OF FIGURE

LIST OF TABLE

List of Abbreviation

1. UF	Ultrafiltration
2. SCBM	Sweet cream Buttermilk
3. BSM	Buffalo Skim milk
4. HCT	Heat Coagulation Time
5. BHA	Butylated hydroxyl anisole
6. LFCW	Low fat coffee whitener
7. HFCW	High fat coffee whitener
8. TS	Total Solid
9. LA	Lactic acid
10. BIS	Bureau of Indian Standard
11. BMS	Buttermilk Solid
12. WHC	Water holding capacity
13. FAC	Fat absorption capacity
14. MFGM	Milk fat globule membrane
15. SNF	Solid not fat
16. UHT	Ultra high temperature
17. WPC	Whey Protein Concentrate

सारांश

दूध सफेदक प्रायः ताजे दूध, मलाई एवं वाष्पीकृत दूध के बदले में चाय/कॉफी/कोको एवं चॉकलेट पेय में प्रयोग किया जाता हैं। इसके अतिरिक्त यह अन्य खाद्य पदार्थ जैसे : सूप, सॉसेस, पुडिंग और अनाजयुक्त भोज्य पदार्थ में भी प्रयोग किया जाता है। यह भारतीय दूध बाजार में अधिक तेजी से बढ़ने वाला उत्पाद है, जिसकी वृद्धि दर लगभग 10 प्रतिशत प्रतिवर्ष है। अल्ट्राफिल्ट्रेशन जोकि एक दबाव संचालित एवं झिल्ली संसाधित प्रक्रिया है, अधिक प्रोटीन मात्रा वाले दूध सफेदक को बनाने में अहम् भूमिका निभाती है।

वर्तमान समय में लगभग 350 मिलियन कि.ग्रा. छाछ भारत में उत्पादित होता है, जिसमें से केवल 8-10 प्रतिशत छाछ ही दूध चूर्ण बनाने में प्रयुक्त किया जाता है। हमारे देश में उत्पादित छाछ का बहुत बड़ा हिस्सा व्यर्थ ही बहा दिया जाता है। भारत के दूध प्लांट में जहां गाढ़ा और दूध चूर्ण बनाने का संयंत्र है, वहां पर छाछ के कुछ भाग को दूध चूर्ण बनाने में प्रयोग करते हैं। छाछ को भैस के वसा रहित दूध में मिलाकर दूध सफेदक बनाया जा सकता है। जिसकी वजह से भोज्य पदार्थों में एक नई प्रक्रिया को जोड़ा जा सकता है। अतः वर्तमान अध्ययन इस तथ्य को सोचकर एक अच्छे गुण वाले वसा रहित दूध सफेदक अवक्षेपित सांद्रित छाछ से बनाया जा सकता है। ताप स्थायित्व का किसी भी भोज्य पदार्थ के निर्माण में अहम् भूमिका होती है। अतः अवक्षेपित सांद्रित छाछ की ताप स्थायित्व की जांच की गई और उसमें सुधार लाने के लिए विभिन्न प्रकार के ताप स्थायित्व प्रदान करने वाले रासायनिक पदार्थ मिलाया गया जैसे : ट्राई सोडियम साईट्रेट, मोनो एवं डाई सोडियम फॉस्फेट मिश्रण (2:1) एवं डाई पोटाशियम हाईड्रोजन फॉस्फेट आदि। अंततः डाइपोटाशियम हाईड्रोजन फॉस्फेट ताप स्थायित्व को बढ़ाने के लिए उपयुक्त पाया गया। अवक्षेपित सांद्रित छाछ अच्छी सफेदक एवं दिखावट देती है, लेकिन अपना सुगंध चाय और कॉफी में प्रदान करती है।

अतः सुगंध में सुधार लाने हेतु विभिन्न अनुपात में अवक्षेपित सांद्रित भैस का वसा रहित दूध ा को अवक्षेपित सांद्रित छाछ में मिलाया गया एवं 67:33 के अनुपात को उपयुक्त पाया गया। इस अनुपात में चीनी मिलाने से ताप स्थायित्व में कमी पाई गई। इसलिए उसमें विभिन्न प्रकार के ताप स्थायित्व प्रदान करने वाले रासायनिक पदार्थ को मिश्रित किया गया। अंततः डाइपोटाशियम हाईड्रोजन फॉस्फेट का चयन किया गया, क्योंकि इसके मिलाने से स्थायित्व में वृद्धि होती है।

खाद गुणवत्ता ताप स्थायित्व और रंग-गुणों के आधार पर वसा रहित दूध सफेदक का निर्माण किया गया एवं भौतिक व रासायनिक गुणों का अध्ययन भी किया गया। इस तरह बनाये गये वसा रहित दूध चूर्ण में ठोस पदार्थ 25.98 प्रतिशत, वसा 0.8 प्रतिशत, प्रोटीन 16.13 प्रतिशत, लैक्टोस 2.75 प्रतिशत, चीनी 3.88 प्रतिशत और भस्म 1.92 प्रतिशत, स्टैबलाईजर 0.5 प्रतिशत पाया गया। इस प्रकार बनाये गये दूध सफेदक की खाद्य एवं सफेदी गुणवत्ता चाय एवं कॉफी में प्रयोग करने पर बाजार में पाये जाने वाले नमूने से बेहतर पाया गया।

Abstract

Dairy whitener is widely used as a substitute for fresh milk, cream or evaporated milk in tea, coffee, cocoa or drinking chocolate and is also suitable for adding to foods like soups, sauces, puddings and cereal dishes. It is one of the fastest growing segments in Indian dairy market with a growth rate of 10 % per annum. Ultrafiltration (UF), which is a pressure driven cross flow membrane process plays a vital role in formulation of dairy whitener with high protein content. At present about 350 million kg of buttermilk are estimated to be available for utilization in India and only part of buttermilk (8-10 %) is utilized along with skim milk for the manufacture of milk powder. A major portion of buttermilk in our country is still drained. In India, dairy plants having condensing and drying units are mostly diversifying to the production of dairy whitener. Buttermilk could be mixed with buffalo skim milk for conversion to dairy whitener.

With a view to add one new variety to the food system, the present study was undertaken to formulate good quality non-fat dairy whitener using sweet cream buttermilk (SCBM) retentate as a base. Heat stability plays a vital role in formulation of any food. Therefore, heat stability of buttermilk retentates was investigated and tried to improve by adding different level of stabilizers such as trisodium citrate, mixture of mono & disodium phosphate (2:1) and dipotassium hydrogen phosphate. Finally, dipotassium hydrogen phosphate was found suitable. SCBM retentate gave good whitening ability and appearance but imparted its own flavor in Tea/coffee. So, different proportion of buffalo skim milk retentate and SCBM retentates was admixed to improve flavor and 67:33 proportions of buttermilk retentate and skim milk retentate was found optimum. Addition of sugar in selected proportion of SCBM and buffalo skim milk retentate was observed to decrease heat stability. It was improved by adding different stabilizers and finally dipotassium hydrogen phosphate was selected because it gave better heat stability. On the basis of sensory scores, heat stability and color parameters liquid non-fat dairy whitener was formulated and it was analyzed for its physico-chemical property. The gross chemical composition of the optimized formulation was total solid 25.98%, fat 0.8%, protein 16.13%, lactose 2.75%, sugar 3.88%, stabilizer 0.5% and ash 1.92 %. The formulation had better sensory score & color parameter in tea/coffee than market sample.

1. INTRODUCTION

Majority of people take tea or coffee in India. The availability of milk for this purpose all the time is difficult particularly in the absence of refrigeration facilities in many households. Dairy whitener is widely used as a substitute for fresh milk, cream or evaporated milk in tea, coffee, cocoa or drinking chocolate and is also suitable for adding to foods like soups, sauces, puddings and cereal dishes. The Dairy whitener should possess good whitening ability, feathering resistance and emulsion stability. These are produced in fluid, condensed and dried forms and differ widely in their formulation. According to one report in Indian Dairyman (Chopra, 1995), dairy whitener has been one of the fastest growing segments in Indian dairy market with a growth rate of 10% per annum. However, the dairy whiteners available in the market are not only costly but also are of poor quality. A majority of Indian population cannot afford them.

India is the largest milk producer in the world. According to one report (IDF, 2004), the total world milk production is 612.1 million tones and share of India is 91.3 million tones. O'Connell and Fox, (2000), reported the worldwide buttermilk production to be 6.5 million tones per annum. The exact figure of buttermilk production in India is not available. However based on conversion of 6.5% of total milk production into creamery butter, it can be calculated that about 372 million Kg of buttermilk is produced annually as a byproduct. This byproduct is a very delicious, exotic and nutritious. It contains all the non-fat components present in milk like casein, whey protein and lactose. The composition of SCBM is almost similar to that of skim milk except for its higher amount of phospholipids and fat (Webb & Whittler1972). Although the nutritional and functional value of skim milk components is well understood, buttermilk has recently gained attention as a potential source of functional ingredients.

The phospholipids of buttermilk include more or less equal proportion of lecithin, sphingomyelin, and cephalin together with small proportion of cerebrosides. Lecithin is widely used to stabilize the fat components of the products and has health benefits such as prevention and curing of memory loss, high blood cholesterol and nervous disorder (Brown, 1990). Sphingomyelin prevents water loss through skin, genetic disease and lowers blood cholesterol level. The famous classified Ayurvedic medicine "Takrarishta", in which buttermilk is the chief ingredient, is helpful in many diseases such as gastrointestinal upsets,

acute and chronic condition and first-degree piles with bleeding or non-bleeding. In jaundice and alcoholic liver diseases, regular use of buttermilk immensely helps the patients to regain appetite (Anon, 2003).

In spite of high nutritional traits, the use of buttermilk has not been fully exploited. At present only 8-10 % of total buttermilk production is utilized in spray drying with skim milk in organized dairies (Pal and Garg, 1989). A considerable amount of buttermilk in our country is still drained. In India, dairy plants having condensing and drying units are mostly diversifying to the production of dairy whitener. Buttermilk could be mixed with milk for conversion to dairy whitener. However no study on suitability of buttermilk for use as a dairy whitener has yet been reported.

Ultrafiltration (UF), which is a pressure driven cross flow membrane process can play a vital role in formulating dairy whitener with high protein content. This process has many advantages like energy saving, process simplification, recovery of whey protein and reduction of pollution hazards. In recent years, UF process is widely used in the manufacture of various dairy products like *chhana, srikhand, paneer,* cheese, WPC, low lactose powder etc.

Dairy whiteners available in the market are generally of poor quality. Further, health conscious people prefer low fat products. The development of non-fat dairy whitener using ultrafiltered buttermilk as a base has merit and scope. Proper utilization of buttermilk, particularly in this value added products would, not only conserve the valuable nutrients, but also minimize dairy effluent disposal. Considering all these points, the present investigation is being proposed with the following objectives

1. To formulate a good quality non-fat dairy whitener using UF sweet cream buttermilk retentate as a base.

2. To optimize the proportion of buttermilk and skim milk and process parameters for formulation of non-fat dairy whitener.

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3. To study the physico-chemical and sensory properties of the product as such and in tea /coffee.

2. REVIEW OF LITERATURE

A very limited published literature were available relating to this project work. However efforts were made to collect all the available pertinent information and presented it systematically.

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2.1 Dairy whitener

This is a product obtained through proprietary formulations by blending high quality ingredients. The primary function of dairy whitener is to impart the desired white color to the beverage (coffee, tea) to which it is added, it also imparts a desirable flavor and body to the beverage. Dairy whitener available in the western countries is in the three forms powder, liquid & frozen.

2.2. Definition of Dairy Whitener (Sweetened Partly Skimmed Milk Powder)

The product prepared by spray drying of cow milk, Buffalo milk or a mixture there of. The milk may be modified by partial removal/substitution of milk solids (non-fat) with carbohydrates such as sucrose, dextrose or dextrine.

2.2.1. Description

The product shall be white or light cream in color, uniform in composition & Free from lumps except those that break up readily under slight pressure and shall be reasonably free from scorched particles.

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2.3. Requirements

2.3.1. Extraneous matter

The product shall be free from extraneous matter, added colors and flavors.

2.3.2. Added salts

The product may contain added calcium chloride, citric acid and sodium citrate, sodium salt of ortho phosphoric acid and polyphoshoric acid not exceeding 0.3 % by mass of the finished product. Butylated hydroxyanisole (BHA) not exceeding 0.01 % by mass of the finished product may be added. Such additions need not be declared on the label. Lecithin may also be added up to 0.5%. This shall be declaring on the label.

2.3.3. Lecithin

Lecithin may be added upto 0.5%. This shall be declaring on the label.

2.3.4. Stabilizer/Emulsifier

It may contain permitted stabilizers and emulsifiers.

2.3.5. Flavor

The flavor of the product or of the reconstituted milk shall be pleasant and sweet. It shall be free from off flavors. It may have slightly cooked but not the burnt flavor. It is recommended that the flavor and taste may be judged on the basis of their sensory characteristics. (IS: 10030)

2.4. Hygienic Condition

The material shall be manufactured and packed under hygienic condition (IS: 2491)

2.5. Microbiological requirements

2.5.1.Colony count

The colony count per gram of the product shall not more than 40 000 when determined according to the method prescribed in IS 5402.

2.5.2. Coliforms/E.coli/staphylococcus

Coliform count, E.coli and staphylococcus aureus (coagulase- positive) when tested in accordance with the method given in IS: 5401, IS: 5887 (part I), and IS: 5887 (Part 2), respectively shall be absent in 0.1 gm.

2.5.3 Salmonella

Salmonella when tested in accordance with the method given in IS: 5887 (Part 3) shall be absent in 25 gm.

2.6 Requirements of Dairy whitener (BIS 1998)

The requirements of dairy whiteners are given in Table 2.1.

Table 2.1. Requirements of Dairy whitener (BIS 1998)

Sl.No.	**Characteristic**	**Requirements**	**Method of Test Ref to**
1.	Moisture, percent by mass, Max	4.0	IS: 11623
2.	Milk solid (non-fat) percent by mass, Min	57.0	See Note
3.	Insolubility Index, ml, Max	1.5	IS: 12759
4.	Total ash (on dry basis) Percent by mass, Max	5.5	Annex B of IS: 14433 (Part I)
5.	Milk fat, Percent by mass, Min	20.0	IS: 11721
6.	Acid insoluble ash, Percent by mass, Max	0.1	Annex C of IS: 14433 (Part I)
7.	Total added sugar (as sucrose), percent by mass, Max	18.0	Annex C of IS: 4079

Note: -Milk solid (non-fat) may be calculated by the formula: 100- (moisture + fat + total added sugar)

2.7. Composition of Ultrafiltered non-fat Dairy Whitener

Compositions of Ultrafiltered non-fat Dairy Whitener and dried dairy whiteners are given in Table 2.2 and Table 2.3.

Table 2.2. Composition of Ultrafiltered non-fat Dairy Whitener

Constituents	(%)
Total solid	20.90
Milk fat	0.39
Milk protein	15.16
Lactose	3.81
Ash	1.71

Lait (2002)

Table 2.3. Composition of dried dairy whitener

Constituents	Percentages	
	LFCW	HFCW
Fat	12.4	48.4
Sod.Caseinate	37.0	20.8
Glucose Syrup	37.0	20.8
GMS	5.6	3.8
CMC	1.2	0.7
Trisodium Phosphate	1.2	0.7
Trisodium citrate	2.5	1.4

(Mathur, 1986)

LFCW –Low fat coffee whitener

HFCW- High fat coffee whitener

2.8. Ingredients of dairy whiteners and their roles

2.8.1. Protein

Protein serves multifunction in whiteners. It provides whitening power, imparts body, has feathering resistance, and improves flavor by contributing a flavor of its own and by reducing the acridity of the tannic acids. It also forms complexes with the tannins in the coffee and improves the taste and lessens the astringents mouth feel. The amount of protein used in the formulation should be enough to completely envelop the fat globules with a hydrophilic membrane, as the total surface area of globules is very large owing to their larger size that is 0.7 –1.0 micron. (Van Eijk, 1987)

Generally milk protein or sodium caseinate is used in dairy whitener ranging from 4 to 9%, however Sodium caseinate is very effective in preventing the feathering of dairy whitener produced from ultrafiltration. Potassium caseinate can be used as an alternative to sodium caseinate. The approx percentage of Sodium caseinate to prevent feathering is 3-15%. (BUCHHEIM). The colloidal solubility of the protein can be affected by many factors including processing methods. One of the most common factors adversely affecting protein stability is a relatively high level of calcium and/or magnesium ions. Calcium is known to induce agglomeration and coagulation of casein fraction, which is attributed to dehydration and micelle formation. Protein may develop off flavors and odors on storage due to either oxidation effects in residual fats or the action of moisture. To overcome these problems, the use of animals proteins, hydrolyzed gelatin can be used which has no gelatinizing action (with O bloom) but possess emulsifying and water binding effects.

2.8.2. Sugar/Carbohydrates

Sugar imparts sweet taste and improves body. It also reduces freezing points of the emulsion and contributes to the caloric value. Normally, sucrose, dextrose and lactose may be used at low levels without altering viscosity or body. If an increase in viscosity and body is desired, corn syrup solids may be used. Those of a low dextrose equivalent will generally impart more body and viscosity and less sweetening effect, due to higher dextrin and lower sugar content. (Knightly, 1969). Meiji Milk_Products Co. (1978) used starch dehydrate in

formulating coffee whitener. Sugars are generally used as the principal carrier to retard coalescence of fat, however, care must be taken to select moisture impervious packaging material when corn syrup solids are included, owing to their hygroscopic nature.

2.8.3. Fat

Fat is the Main constituent of dairy whitener. It imparts whitening power, body, and viscosity to the product. The whitening effect produced in coffee, primarily as a result of light reflected from the surface of the finely emulsified fat globules. (Sommer)

In dairy whiteners the fat source is essentially the milk fat. The milk fat though quite bland in taste imparts richness/smoothness to the dairy whitener. While formulating dried powders, relatively higher temperature melting fats (melting point 43-46^{0}C) with low amount of unsaturated fatty acids are used to prevent "oiling off " problems. In liquid whiteners, low temperature melting fats (melting point 35 – 37^{0}C) are used as high temp melting fat give fatty/waxy after taste particularly when used in cold foods.

In coffee whitener, there is wide range of proportion of fat are used. Kubota et al (1978) used 28-60% of an edible oil in the preparation, While Gibson and Sharma (1965) recommended use of skim milk concentrate (33% solids) as coffee whitener, Keeping quality of such products was more than the samples with 4%, 8%, or 12% milk fat. The ingredients cost of non- fat and low fat dairy products was lower than those of common non-dairy coffee whiteners (Hedrick and Armitage, 1964)

2.8.3.1. Role of fat in dairy whiteners

The fat imparts whiteness to the dairy whitener (Sommer). Since fat is the constituent of the dairy whitener it has, most pronounced effect on the coloring power. The effectiveness of fat content, in producing color varies with the size of the fat globule. The surface area of the given amount of fat is inversely proportional to the radius of the globule. Thus the light-reflecting surface of a 10-micron globule is in creased to 10 fold when it is scattered to produce 1000 globules with diameter of 1 micron

2.8.4. Stabilizing salts

Addition of stabilizing salts to concentrated milk before sterilization is common practice. It is noticed that stabilizing salts are necessary to be added so as to arrest the heat coagulation during sterilization for the manufacture of a satisfactory commercial milk concentration. However, no optimization of the levels of stabilizers has been done and the pilot sterilization is the most suitable method used in dairy industry today. Stabilizers, which are hydrophilic colloids, are primarily needed to improve colloidal stability of protein. A secondary function of hydrocolloids is to imparts body and increase viscosity, particularly in liquid whiteners, where as, in powders whiteners, addition of stabilizers is not absolutely essentials (Knightly, 1969). Carrageenan which forms complex with protein is the best suited to improve colloidal solubility, where as carboxymethyl cellulose, alginate, guar gum and some other stabilizers controls body and viscosity. Certain phosphate and citrate salts are improve the colloidal solubility of proteins (Sommer et al, 1923) and reduce the tendency toward syneresis. The disodium or dipotassium salts of phosphoric acid are most commonly used, although other sodium and potassium phosphates are suitable. Sodium aluminum phosphate has been reported as being particularly effective (Stauffer Chemical Co, 1986).

The use of phosphate salts is particularly desirable when the water used for manufacture, is high in calcium or magnesium. However, their use at level in excess of that required to counter act the metal ions may so solubilize the protein as to induce gelling. Such salts are usually used at 0.10- 0.15% based on total fluid weight. The use of higher levels, to reduce syneresis with protein of below average “solubility” may impart an excessively salty flavor and should be approached with caution. The use of deionized water may obviate the need for these salts.

2.8.4.1. Monosodium Phosphate

Sindhu (1985) observed that monosodium phosphate caused a considerable increase in the heat stability determined as HCT (130^{o}C) of concentrated buffalo milk. The optimum concentration of this salt for imparting maximum stability to the concentrate was different for different samples. The pH of concentrated milk containing added monosodium phosphate was significantly lower than that of the control (no added phosphate). With the addition of an

appropriate concentration of monosodium phosphate (from 0.5 to 1.5%), it was possible to manufacture evaporated milk up to 36% total solids

2.8.4.2. Disodium Phosphate

Prasad and Balachandran (1987) reported that the addition of disodium phosphate increased the heat stability of buffalo milk concentrate along with the average value for the pH. The highest values for HCT were obtained at 25% TS with a stabilizer concentration of 0.3% stabilizers. The milk concentrate was found to withstand batch sterilization (120^{o}C from 15 min holding time) at 30 and 35% TS.

Sindhu and Tayal (1986) observed that there was significant increase in pH of concentrated milk, which was progressive with increase in the concentration of added salt due to which it decreases the heat stability of buffalo milk concentrate. The HCT-pH profile of one of the samples of concentrated buffalo milk is evident that the unadjusted pH of buffalo milk (6.8) lay on the alkaline side of the pH maximum stability (6.7) in the HCT pH profile. Similarly for concentrated milk the unadjusted pH was 6.7 and the pH of maximum stability 6.6. Addition of either disodium phosphate or trisodium citrate caused a considerable decrease in the heat stability of buffalo milk or its concentrate at unadjusted pH

2.8.4.3. Trisodium Citrate

Citrate (0.15%) increased the heat coagulation time for fresh buffalo milk (80.4 to 171.8 min) and cow milk (45.5 to 51.5 min) as reported by El-Shazly and Khalafalla (1978). Tri-sodium citrate at the same level was found to increase HCT of concentrated milk to a lesser extent (Prasad and Balachandran 1987b). They further reported that the average value for the pH and the HCT increased marginally compared to control sample.

Tayal (1983) and Sindhu and Tayal (1984) had revealed that instead of acting as stabilizers disodium phosphate and sodium citrate act as strong destabilizing agents when added to buffalo milk. Sindhu and Tayal (1984) also reported that the disodium phosphate and trisodium citrate caused a significant increased in pH of fluid milk and its concentrate

and the increase was progressive with the increase in concentration of added salts, with the decrease in the heat stability of buffalo milk and its concentrate.

2.8.4.4. Sodium Hexametaphosphate

Prasad and Balachandran (1987) observed that with the addition of sodium hexametaphosphate, the average values for the pH and the HCT decreased. The decreased in the pH values were observed with further increase in concentration of this salt for the 25, 30 and 35% TS concentrate. The addition of anions particularly phosphates are widely used to improve stability of evaporated milk during sterilization and storage. The 0.1% concentration of sodium hexametaphosphate improved the stability of skim milk concentrates with various solids content. However, increasing the added salt to 0.2% did not improve the stability above the control (Metwally et al., 1978). Concentrated buffaloes skim milk was more heat stability than cow skim milk when both were preheated to 190 or 206^{o}C for 20 min and concentrated 22.5% TS (Met Wally et al., 1978).

2.8.4.5. Dipotassium hydrogen phosphate

Grutzmacher and Bradley (1991) reported that addition of dipotassium phosphate was necessary to prevent precipitation of protein exposed to hot acidic condition of instant coffee. A dipotassium phosphate to protein ratio of 1.0 yielded good stability in whiteners with sodium caseinate replaced by acid whey concentrate. Addition of 0.3% potassium phosphate dibasic was reported in whiteners made from succinylated cheese whey protein concentrate (Thompson and Reiners, 1982). In one earlier patent (Gardiner, 1977b). The incorporation of a mixture of sodium carbonate and dipotassium hydrogen phosphate in dried non- dairy creamers containing 3 to 15% (by weight) of sodium caseinate is claimed to increase the feathering resistance of such creamers when added to coffee.

2.8.5. Other additives

In addition to the main ingredients other ingredients including flavor, color and free flowing agents to further improve the acceptability of dairy whitener have been reported. Sufficient flavor and color may be added to meet the consumer demands. Some excellent flavors are available, however many offered for this purpose contain too high a level of butter

flavor such as diacetyl which may lead the consumer to believe that some spoilage has taken place (Knightly, 1969). Addition of cream flavors has been reported by various workers (Van Eijk, 1987; Thompson and Reniers, 1982; McKenna et al., 1988; Gruetzmacher and Bradley, 1991). Addition of riboflavin and/or B-carotene (Jimenez Florez and Kosikowski, 1986) and titanium dioxide (Gruetzmacher and Bradley, 1991) have been reported to improve the whitening power of the coffee whiteners

2.9. Buttermilk

Buttermilk is an important byproduct of butter industry. The nutritive and functional properties of the product are well documented (Pal and Rajorhia, 1985). The nutritive value of buttermilk is as high as fermented milk and favors the opinion of diet conscious people since it contains very less quantity of fat.

2.9.1. Chemical composition of buttermilk

The chemical composition of buttermilk varies to a great extent, depending on the amount of water added to cream. Some of the butter manufacturers standardize cream with water, thereby decreasing the total solids level of buttermilk. The chemical composition of buttermilk produced under ideal conditions almost similar to that of skim milk.

Table 2.4. Average composition and Physico-chemical properties of sweet cream buttermilk and buffalo skim milk

Characteristics	Skim milk	Buttermilk
TS (%)	10.18	9.88
Fat (%)	0.09	0.59
Total protein (%)	4.27	3.73
Lactose (%)	5.2	4.81
Ash (%)	0.82	0.75
Total phospholipids (mg %)	8.65	78.56
Titratable acidity (% LA)	0.16	0.12
PH	6.69	6.86
Curd tension (g)	66.85	18.84
Relative viscosity (cp at 30^0C)	1.64	1.8
Surface tension (dyne /cm^2)	49.42	44.27

Sour buttermilk differs from sweet cream buttermilk in respect of titratable acidity. The acidity of SCBM varies from 0.1 to 0.14%, whereas in sour buttermilk it is more than 0.15% and even as high as 1%. However, there is not much difference in the chemical composition of two types of buttermilk. Desi buttermilk has wide range of composition depending on the quality of milk used for making curd and levels of addition of water during churning. Desi buttermilk on an average contains 4% total solids comprising of 0.8% fat, 1.29% protein and 1.2% lactic acidity.

Table 2.5. Some compositional properties of skimmed milk and skimmed buttermilk

Type of milk	Skimmed milk	Skimmed buttermilk
Ca^{2+} (mg/kg)	1195 ± 93	948 ± 54
Total protein (%wt/vol)	3.32 ± 0.21	3.12 ± 0.14
pH 4.6-soluble protein (% total)	24.4 ± 1	25.0 ± 3.2
Non micellar casein (% total casein)	9.2 ± 2.0	12.0 ± 5.5
Non micellar casein profile (% total non micellar casein)		
α-CN	32 ±3	15 ± 3
β-CN	46 ±4	41 ± 8

(O'Connell and Fox, 2000)

2.9.2. Functional properties

2.9.2.1. Water holding and fat absorption capacity

The WHC of proteins has an important role in the physical (e.g., elasticity, swelling), chemical (e.g., emulsification) and sensory (e.g., juiciness) attributes of foods. Fat absorption capacity (FAC) is the binding of fat by non-polar amino acids present in the side chains of proteins (Susheelamma and Rao, 1974). The affinity of protein to bind fat improves the texture and reduces yield losses in fabricated foods such as comminuted meat or bakery products. The FAC of Buttermilk solids (BMS) had a slightly lower initial fat content would result in an increase potential to bind more fat (Lin and Zayas, 1987). Another possible reason for the superior FAC can be explained by the significant level of sulfhydryl groups, which

indicate a denatured and unfolded protein molecule with hydrophobic regions for interaction with fat. It appears that dairy proteins (i.e., casein and whey) in milk powders have a greater role in fat absorption than MFGM specifically (Wong P. Y. Y. and Kitts D. D. 2003).

2.9.2.2. Foaming capacity and stability

Foaming is the incorporation of air into an aqueous medium by means of physical agitation and aeration. Protein foams are important to several categories of foods, including meringues, whipped toppings, and leavened bakery products. The primary functions of proteins in a foam is to decrease the interfacial tension at the air/liquid interface to facilitate the incorporation of air into the liquid phase and to stabilize the resulting foam by forming a cohesive film around the air droplets. An increase in protein content from BMS has been reported to have no effect on the foaming capacity (Sather et al., 1982). Therefore, several other physicochemical factors, such as protein solubility, surface charges, protein denaturation, surface hydrophobicity, size of protein, and flexibility of protein molecule also have been known to affect foaming capacity and stability (Kinsella, 1976). Greater foam stability established by protein powders in the isoelectric region has been attributed to the low net charge that decrease intermolecular repulsions and the greater association of denatured protein molecules to form a stable and cohesive film around air droplets (Zayas, 1997). However, protein molecules at isoelectric point are less soluble and protein solubility is a factor for foaming capacity (Hettiarachchy et al., 1996; Ahmedna et al., 1999). A more likely explanation for the difference in foaming capacities related to the significant relationship obtained between foaming capacity and sulfhydryl group content. Townsend and Nakai (1983) reported that proteins are extensively uncoiled at the air/water interface, and this is the major reason for the increased foaming capacity of proteins with relatively high surface hydrophobicity. Moreover, the extent by which denatured proteins unfold to adequately interact with the entire interface is also a critical factor in foaming capacity (Towsend and Nakai, 1983).). Therefore, the presence of the MFGM may have displaced the proteins in BMS from the air/water interface, or interacted with the partially denatured proteins (through hydrophobic interactions) that are also required in foaming.

2.9.2.3. Emulsifying capacity and stability

An o/w emulsion is a suspension of fat droplets in water that is stabilized by a surface-active agent or emulsifier at the o/w interface. Therefore, the ability of a protein to act as an emulsifier will depend primarily on its amphipathic nature, in addition to other factors such as solubility of protein, degree of surface denaturation, lipid-to-protein ratio, and its effect on emulsion viscosity. Because buttermilk contains various fractions capable of emulsification (e.g., MFGM, ß/κ-casein, and whey proteins), the hypothesis that commercial BMS can act as a natural emulsifier was examined under various conditions of protein content, lipid-to-protein ratio, time, and temperature. In general, an optimal emulsifying capacity was achieved with only 0.9 g of protein. Thus, a relatively small but adequate amount of protein was absorbed at the interface to suspend all the oil droplets created by 50% oil concentration, regardless of the shape and relative flexibility of the individual protein sources. Increasing the protein content did not further enhance emulsification capacity, since excess protein is unable to migrate to the o/w interface. Therefore, an emulsification effect did not occur but rather a stabilization effect likely took place through a lipophilic-hydrophilic arrangement (Kanno *et al*., 1991).

At low protein contents in BMS exhibited better emulsifying capacity. This result is contrary to the findings of Ahmedna et al. (1999), but can be explained by the greater emulsifying capacity of BMS resulting from the presence of MFGM that contributes additional emulsifying properties (Corriedig and Dalgleish, 1998; Kanno, 1991). The importance of hydrophobicity in emulsification is well known and the positive correlation obtained between sulfhydryl group and emulsifying capacity can be explained by the increased surface hydrophobicity, which further enhances the emulsification capacity of protein by increasing the attraction towards the o/w interface. Kanno et al. (1991) reported similar findings and concluded that the hydrophobic proteins and phospholipids in MFGM were responsible for the emulsification of fat globules in milk and cream. The greatest emulsifying capacity of BMS was achieved in a 50% o/w emulsion, and any changes in this proportion of oil resulted in a reduction in emulsification capacity. In situations in which low concentrations of oil exist, an excess of protein in the emulsion will favor protein aggregation rather than protein absorption at the o/w interface through hydrophobic interactions. Aggregation of ß-casein and the interaction with amphipathic substances, such as phospholipids, is a good example of the adverse effect of excess protein content on emulsion

stability (Fang and Dalgleish, 1993). Moreover, the inverse correlation between WHC and emulsifying stability suggests an increased interaction between protein and water in the emulsion that has a low oil concentration (e.g., 10%).

By increasing the relative concentration of oil in the emulsion, an opposite phenomenon would be expected in which coalescence of the oil droplet reduces protein absorption at the interface, resulting from greater hydrophobic attraction between oil droplets. Corredig and Dalgleish (1998) demonstrated that approximately 50% of the absorbed protein at the o/w interface from a BMS emulsion came from caseinate fractions, of which ß-casein predominated due to its extremely hydrophobic nature. The absorption of casein, whey, and MFGM protein at the interface has also been shown to be dependent on the ratio of the three proteins present in the dairy powder (Corredig and Dalgleish, 1998). A strong correlation between emulsion stability over time and pH was also established. Pearce and Kinsella (1978) reported an increased instability of a whey protein stabilized emulsion at pH values over 5.5. The emulsifying stability of MFGM in reconstituted milk fat was also enhanced under alkaline condition (Kanno, 1989). The apparent destabilization of emulsions under acidic condition was observed and in others, is caused by the aggregation of absorbed protein at the o/w interface near the isoelectric points of pH 4 to 5 for dairy proteins, which exposes the oil droplets surface for flocculation leading to de-emulsification (Kanno, 1989).

2.9.2.4. Antioxidant properties of buttermilk

Lipid oxidation of monounsaturated and polyunsaturated fatty acids in foods during processing and storage is a major concern to the food industry. The oxidation of unsaturated fatty acids results in the formation of peroxides, which are susceptible to further decomposition to secondary oxidation by-products, such as short-chain aldehydes and ketones. The presence of these molecules, reacting with oxygenated compounds in foods, will adversely affect flavor, taste, nutritional value and overall quality (Vercellotti et al., 1992). The antioxidant potential of proteins derived from dairy products is known (Allen and Wrieden, 1982; Colbert and Decher, 1991; MatStuchell and Krochta, 1995 et al., 1996). Allen and Wrieden (1982) showed that casein had antioxidant activity at concentrations relevant to bovine milk sources, whereas whey was less effective at similar concentrations. Antioxidant activity of milk proteins was proposed in part to be due to the sequestering of iron and copper metals by the phosphoseryl residues located on the surface of the casein micelle.

Other workers have suggested that whey proteins donate hydrogen to reduce free radicals (Colbert and Decker, 1991), and that free sulfhydryl groups from cysteine are effective at inhibiting lipid autoxidation (Taylor and Richardson, 1980a, 1980b). Furthermore, the presence of antioxidant enzymes (e.g., superoxide dismutase and catalase) and nonenzymatic antioxidants (e.g., tocopherols, carotenoids, citrate, phosphate, and ascorbic acid) in milk may also contribute to the overall antioxidative effect observed by others (Richardson and Korycka and Dahl, 1983). However, xanthine oxidase, derived from cream, has been demonstrated to induce lipid oxidation in a linolenic acid model system by the production of superoxide anion (Kellogg and Friderich, 1975). The actual significance of xanthine oxidase prooxidant activity to promote oxidation in foods may vary, depending on the presence of superoxide dismutase enzyme that scavenges superoxide anion. Buttermilk is the liquid byproduct derived from the churning of cream into butter. It has a composition similar to that of skim milk, therefore, containing both casein and whey proteins in addition to a small amount of fat. The antioxidant activity of the BMS at 0.1 and 0.2% was shown to inhibit lipid oxidation by 56 and 61%, respectively, using a simple peroxidizing model system. 10mg.

2.10. Ultrafiltered skim milk

Ultrafiltration is a pressure driven membrane filtration process that facilitates the selective separation of protein from lactose salts and water under mild condition of temperature and pH. It is a physicochemical separation technique in which a pressurized solution flows over a porous membrane that allows the passage of only relatively small molecules. The retained solution flows over the membrane, while under the influence of pressure water flows through the membrane, together with low molecular weight, solutes. The protein is retained by the membrane and is therefore concentrated relative to the other solutes in the retentate. Casein in whey proteins, because of the larger size will not pass through and become a part of retentate stream. This protein retentate is a relatively new product based upon ultrafiltration. Typically with the protein purity of 50 - 85% milk protein retentate can be considered as a functional ingredient to be used in the manufacture of dairy whitener. Fat globules and suspended solids are also retained. Skim milk is obtained by removing cream from the whole milk. Since cream is mostly fat, skim milk is essentially defatted milk. Normally skim milk contains 0.1- 0.2% fat and 8.5 - 10% milk solid not fat.

Ultrafiltration of skim milk is used to produce popular new dairy products and dairy based foods that are higher in protein and lower in carbohydrates.

Table 2.6. Percentage composition of skim milk and retentate

Constituents	TS	Protein	Lactose	Ash
Skim milk	9.31	3.32	5.10	0.86
Retentate1	24.52	17.99	4.21	2.33
Retentate2	22.76	18.01	2.55	2.19

(Patel et al. 1991)

Retentate1-- 5.5 fold concentration of skimmed milk

Retentate2- obtained after diafiltration

Ultrafiltration of skim milk has distinct advantages like saving of energy, improved yield of protein, enhanced nutritive value of the product and availability of lactose stream in the form of permeate. The skim milk retentate is advantageously used as a protein source in the formulation of dairy whitener.

Table 2.7. Composition of retentate obtained from ultrafiltered skim milk (Chemical analysis of retentate)

Volume retentate factor	Total Solids %	Casein %	Whey Protein %	Lactose %	Ash %
X1	8.5	2.8	0.28	5.1	0.74
X2	12.1	5.7	0.65	5.0	0.99
X3	15.5	8.4	0.91	4.7	1.26
X4	18.9	11.5	1.15	4.7	1.37
X5	21.8	13.8	1.41	4.5	1.70

(Glover, 1985)

2.10.1. Changes in the chemical composition during ultrafiltration of skim milk

Premaratne and Cousin (1991) studied the changes occurring in the chemical composition of skim milk during ultrafiltration have to be considered before retentates are used in the manufacture of dairy whitener. Five batches of pasteurized skim milk were concentrated to approximately 2-fold, 4-fold & 5- folds by ultrafiltration. Chemical analysis of the skim milk and retentates were done to determine the change in chemical composition that occurred during ultrafiltration.

a. Milk proteins were concentrated during ultrafiltration from an average of 3.42% in skim milk to 6.85%, 13.51%, & 17.1% in 2-fold, 4-fold & 5-fold retentate, respectively.
b. Milk fat similarly was concentrated from 0.11% in skim milk to 0.24, 0.45, and 0.60 % in 2-fold, 4-fold and 5- fold retentates, respectively.
c. Lactose content progressively decreased during ultrafiltration from an initial 5.06% in skim milk to 4.76, 4.29 and 4.06% in 2-fold, 4-fold and 5- fold retentates, respectively.
d. Total solids content increased to a lesser extent, compared with protein and fat from 9.19% in skim milk to 12.72, 17.80 and 23.91% in 2-fold, 4-fold and 5- fold retentates, respectively, reflecting the loss of lactose and other soluble small molecular weight components
e. Partial concentration of skim milk as a results Ca^{++} by 1.6, 3.0, and 4.34, Mg^{++} by 1.4, 2.3 and 3.0 fold, Zn^{++} by 1.8, 3.4 and 4.9 fold, Fe^{++} by 1.9, 3.5 and 4.9 fold, Cu^{++} by 1.7, 3.4 and 4.74, and Mn^{++} by 1.5, 2.0 and 3.0 fold in the 2-fold, 4-fold and 5- fold retentates, respectively.

2.10.2. Heat stability of skim milk concentrated by ultrafiltration

Thermal processing of milk has become an integral step in dairy processing since the first heat treatment given to milk by Pasteur. The stability of milk, especially of the caseinate system, to high heat treatment is of great importance to the dairy product manufacturers, especially in the manufacture of sterilized concentrated milk. The ability of caseinate system to resist heat coagulation for certain time is generally termed as heat stability of milk and the time required to coagulate at a given temperature is known as heat

coagulation time (HCT). The most widely used definition of heat stability is length of time which elapses between the placing of a sample of milk in an oil bath at a definite temperature and the onset of coagulation as indicated by flocculation, gelation or changes in protein stability. As a measure of heat stability the time of the on set of protein coagulation is observed during heating to 130 ˚C, long time indicating high stability (Sweetsur and Muir, 1980).

In the manufacture of whitener heat stability of SCBM plays a significant role. A number of factors interact in a complex manner, which ultimately determine the heat coagulation of milk. On the basis of findings the role of various interacting factors may be summarized as follows

a. Protein makes up- the larger the amount of β- lactglobulin, the higher the maximum heat coagulation temperature.
b. Salt balance- Heat stability is maximum at the optimum salt equilibrium, defined by relative concentration of calcium, magnesium, citrate and phosphate in ionic form
c. PH- The pH effects both the molecular dissociation of casein components and formation of aggregated protein complexes through protein-protein interactions. Further pH strongly affects the salt equilibrium between the colloidal and ionic state of minerals in milk. Maximum heat stability is observed between pH 6.6 and 6.8.
d. Concentration of milk solids- The heat stability of milk decreases progressively

Factors that generally influence the heat stability of concentrated milk are: (1) Compositional factor: pH, solids, phosphate composition, mineral composition and seasonal variation, (2) Processing factor: preheating, homogenization etc., and (3) Additives or stabilizing salts. As such many of these factors are inter related and not all may be equally significant in relation to milk concentrated by ultrafiltration. The stability characteristics of concentrated buffalo milk are technologically important. The addition of stabilizers contributes greatly to improve the heat stability of a concentrated milk system.

It was shown that the addition of suitable stabilizers and heat pretreatment of buffalo skim milk could induce a significant increase in the heat stability of UF-DF retentate obtained from buffalo skim milk. In general, as concentration increases, heat stability decreases. For skim milk the stability of milk concentrated to 9 -15 % TS by ultrafiltration and evaporation

are same. At 18 % TS, the stability of ultrafiltered concentrate is much better than that by evaporation, the ratio of coagulation times being 2:1. This difference increases at a higher level of concentration. At the equal total solid content of 18.4 %, the concentrate by ultrafiltration and evaporation contains 12.8 % and 7.1 % protein respectively (Sweetsur and Muir, 1980). A concentrate by evaporation containing 12.8 % protein would have a solid content of 33 % and in the heat stability test would coagulate immediately. When compared with evaporated milk the UF concentrate will contain more protein and less lactose and will therefore be more suitable for those unable to tolerate lactose. Due to their lower content of lactose they will also be less susceptible to maillard reaction during processing and storage.

Kosikowski, (1983) reported that milk concentrated by ultrafiltration keeps better then normal milk. This has been shown by concentrating milk up to three fold, pasteurizing and then storing at 4˚ C. Comparison was made with other milk from same source also pasteurized but not concentrated. At 4-5 days normal milk developed an oxidized flavor while the concentrate remained excellent. After 7-8 days the normal milk became unmarketable and yet a flavor of the concentrate was good for up to 20 day

When skim milk is concentrated, the stability of the whey protein fraction is improved. As the total solids in the milk were increased from 9 - 44 % by approximately 11-fold concentration, whey protein denaturation during heating at 80˚ C for 20 min decreased from 80 -39 % (McKenna and O'sullivan, 1971). The skim milk concentrated to 0.7 times its initial volume by ultrafiltration and stored at –8 ˚ C remained stable 3 times longer than normal skim milk. (Lonergan et al. 1981). After one to three weeks at this temp, the casein destabilized. Removal of lactose by diafiltration and replacement with glucose extended the stability.

2.11. Heat stability of buttermilk

Buttermilk prepared on a laboratory scale from raw cream, or on a commercial scale from flash-pasteurized cream (90°C for 1 to 2 s), exhibited a type B heat coagulation time-pH profile (i.e., stability increased as a function of pH). The high heat stability of buttermilk in the pH range of the minimum of a type A milk (pH - 6.8 to 7.0) appears to be related to

differences in the serum phase constituents (i.e., a low calcium and β-Lg concentration and a high non micellar κ-CN content) (Connell and Fox, 2000).

2.12. Physical properties of dairy whiteners

2.12.1. Feathering resistance

Feathering is the formation of a flocculants of protein and fat complex that separates from coffee solution. Feathering resistance is the ability of a whitener to resist flocculation of proteins in emulsion and subsequent formation of visible particles that separates in hot coffee solution. This is regulated by Ca ions, temperatures and pH of coffee solution. Ca is known to induce agglomeration and coagulation of casein fractions, which is attributed to dehydration and micelle formation (Knightly, 1969).

Consumers almost invariably regard this occurance as indication of partial souring and complain accordingly. While a high acidity will cause feathering, it is by no means the only factor, cream that is of faultless quality in all other respect may show this defect. The scum that floats to the surface of the coffee, the added cream feathers consists of coagulated proteins with enough occluded fat to float the particles. The problem is therefore essentially one of protein stability (Sommer)

2.12.2. Factors affecting feathering

2.12.2.1. Factors relating to the whitener

- **2.12.2.1.1.** Acidity
- **2.12.2.1.2**. Salt composition
- **2.12.2.1.3.** Fat content
- **2.12.2.1.4**. Solid not fat (SNF)

2.12.2.2. Factors relating to coffee

- **2.12.2.2.1.** Acidity or the strength of the coffee
- **2.12.2.2.2**. The proportion of coffee to water
- **2.12.2.2.3**. The age of brewed coffee
- **2.12.2.2.4**. The hardness of water used
- **2.12.2.2.5.** The temperature of coffee
- **2.12.2.2.6.** The amount of cream used

2.12.2.1.1. Acidity

Coffee is a hot acidic system that will restabilize many proteins. Coffee pH ranges from 4.8 to 6.3 at temperature of 50 to 90^{o}C (Giddey, 1967). Lower pH affects not only ionic equilibrium of casein but also its solubility. Flaking out begins at pH around 5.3. Thermal stability of casein complex is impaired by abnormally high concentration of acid and salts. Stabilizers/ Stabilizing salts are needed to improve colloidal stability of protein.

Acidity is a factor in feathering, since an increase in acidity favors curdling of milk or cream. However, the acidity of both the cream and the coffee must be considered. Under average conditions the coffee is more likely to be at fault than the cream. The reaction of 15 samples of coffee served to the public was found to range from pH 4.98 to 5.93 by Sommer. The former value was found on coffee that had been in the run 3.5 hours, the later value on freshly prepared coffee. In the lab, test coffee percolated with tap water had a reaction of pH 6.98 after 1 min of percolation, and pH 5.56 after 15 minutes. These results indicate that the acidity of coffee increases with the time of contact between grounds and the brewed coffee. Undoubtedly inherent differences in the acidity of coffee beans and differences in the proportions of coffee and water are further factors. Milk and cream curdle at room temperature at pH 4.7 to 4.85, it is not surprising to find feathering when cream is added to coffee at higher temperature at which it is served.

2.12.2.1.2. Salt composition of whitener and water

Salt plays an important role in feathering of whitener just as in case of coagulation of milk in cooking. Both whitener and water used in making the coffee are subject to wide variations with respect to this Factor. Calcium and magnesium salts Favours feathering, citrates Phosphates tend to prevent feathering. The extreme difference in hardness of water supplies is well known; the hardness is primarily due to calcium and magnesium salts. A surplus of bivalent ion (Ca, Mg) resulted in flaking and may rise from water hardness in excess of 300-400 ppm Ca / Mg Co_3. A good coffee whitener has a feathering resistance in coffee having hardness of water higher than 400 ppm $CaCo_3$ equivalent at 80^{o}C. The skim milk powder has stability only up to 250 ppm $CaCo_3$ equivalent at 80^{o}C (Early, 1990). Thus, trouble with feathering of cream will vary with seasonal differences in the salt composition of milk or cream and with the hardness of water used in preparing coffee. Softening the water

and the addition of sodium citrate or disodium phosphate to the whitener is helpful measures in preventing Feathering. Sodium citrate is somewhat more effective and is preferable to the phosphate. The addition of two to six ounces of sodium citrate to1000 pounds of cream will prevent feathering unless other causative factors are too severe. When the whitener is of faultless quality in other respect and such additions are made solely to compensate for normal variations in the compositions of milk and whitener. There should be little objection to this practice.

2.12.2.1.3. Fat & SNF content of the whitener

When whitener alone is heated to high temperature (120˚ C) and the coagulating time is noted, it is found that the stability decreases as the fat content, or the SNF content is increased. A high fat content affects the feathering in hot coffee similarly but up to a certain point, an increase in the SNF content tends to prevent feathering. Buchheim (1983) also observed that creams of higher (15 to 20 %) fat content were less resistant to feathering than lower fat (10 to 12creams).

2.12.3. Others factors in feathering

The temperature of the coffee at the time of the addition of the whitener is important. Addition of a large quantity of whitener freshly made show less feathering because of lower temperature and acidity of the mixture. Burgwald, Webb and Holm have found that when the whitener is added to coffee shows more feathering than coffee is added to the whitener.

2.13. Whitening ability

The amount of whitener required to produce a given color effect in coffee/tea varies and occasionally leads to complaints that the whitener is lacking in richness. The whitening power of a whitener determines the amounts to be added to coffee and also provides an index of its richness. Such complaints usually come from users who dispense a measured amount of whitener with each serving of coffee / tea (Sommer and Aneja)

.

The coloring power of cream depends upon the number & sizes of suspended particles in it to produce a whitening effect. The particles must be sufficiently large to reflect and

scatter light. In whitener such particles comprise the fat globules and colloidal particles of casein, calcium phosphate and possibly coagulated albumin. The non-fatty suspended particles are responsible for variations in coloring power of the whitener. Whitaker found that the addition of 3 % SNF to the whitener lowered the amount of whitener required to produce a given color of about 20 %. He also found that pasteurization at 85˚C for 15 sec increased the coloring power slightly as compared with pasteurization at 63˚C for 30 min. This is presumably due to calcium phosphate precipitation and albumin coagulation at the higher temperature, although some fat emulsification may also be involved. Since fat is the constituent of the whitener, it has a very pronounced effect on the coloring power, the higher the fat content, less whitener is required to produce a given color. The effectiveness of a given fat content in producing color varies with the size of the globule. The surface area of a given amount of fat is inversely proportional to the radius of the globule. Thus, the light-reflecting surface of a 10-micron globule is increased 10 fold when it is scattered to produce 1000 globule with diameter of one micron.

The whitening and coloring power of various whiteners were studied quantitatively by employing reflectance spectrophotometer according to the method of Aneja. (1994). Lightness and color parameters were studied on the Hunter scale. The color of prepared coffee was however dependent on the ratio of fat to SNF. Quantification of the contribution to the whitening power of coffee whitener by its constituents can lead to the evolution of an entirely new range of coffee whitener based either largely on SNF or fat. With the fluctuating prices of these milk constituents it should now be possible for the manufacturers to market a standardized product, using various proportions of these constituents without loss of whitening ability.

Whitening is also influence by processing parameter. Whitening ability can be improved by processing condition that produce smaller fat globules and produce more interactions between the fat, emulsifiers and casein, which align at the fat water interface. These interaction and small globules will reflect more light, producing more of the whitening effect in tea / coffee (Gruetzmacher and Bradley, 1991).

Organoleptic evaluation of coffee / tea whitener (dried / fluid) must be done after adding into the beverage and looking for its ability to whiten and develop mouth feel and flavor. The

development of any off-flavor and oiling– off / feathering may also be observed closely as objectionable changes.

2.14. Formulation of Dairy whitener

Most of the information regarding tea/coffee whitener, creamer or coffee cream characteristics and their manufacturing process are available briefly and only in patents. Although the right ingredients in proper proportions and balance are indispensable to the production of a good quality coffee/tea whitener, the condition of processing can introduce changes in the quality of the product that may lead to enhanced or lowered acceptability. Typical formulations for preparation of liquid and dried coffee/tea whitener as reported by various research workers.

2.14.1. Formulation of powdered Dairy Whitener

A low fat dairy tea /coffee whitener based on ultrafiltration retentate of skim milk was patented by Kosikowski and Jimenes (1987). This was made by ultrafiltration of skim milk to a protein concentration of 2:1- 4:1, followed by freeze drying or spray drying of the retentate and addition of a whitening agent. The product comprised of riboflavin and /or B- carotene (10-20 mg/100gm dried retentate) along with 49-65 % protein, 23-28 % lactose, 7.6-7.8 % ash, 3.9-4.6 % moisture, 0.5-.53 % fat, 1.7-2.1 % calcium and 22-35mg/100gm Na. It is claimed that the product provides a similar pH shifting function in coffee, dispersibility and whitening capacity as other commercial whiteners.

A coffee whitener in which palm oil was replaced by cream, comprised 61.79 % corn syrup (DE-42), 25.14 % milk fat, 5.98 % potassium phosphocaseinate, 3.39 % milk SNF, 3.0 % moisture, 0.5 % glycerol monosterate, Vitamin and antioxidants had been standardized by Downes and Pelster (1986). The processing involved, dissolving all the ingredients in hot water, heating to 75^0C, homogenizing at 17.3 and 3.5 Mpa and spray drying. The product had good wet ability, solubility and flavor and did not produce any feathering in coffee.

2.14.2. Formulation of liquid Dairy Whitener

Baker (1987) obtained a UK patent for process standardization of low- calorie coffee whitener based on fluid milk. It is claimed that the product has the appearance; taste and mouth feel of conventional high milk fat creamers/ whiteners, although it was low in fat and energy. The product comprised of less than 1 % milk fat, 8-12 % proteins and 8-12 % carbohydrate. Blending skim milk made it dried skim milk, monoglyceride and titanium dioxide. The blend was homogenized, UHT processed and aseptically packaged in single serve containers.

Baker and Hulett (1988) standardized a method for the manufacture of low fat coffee whitener by using 98-99 % of fluid milk components (85 % skim milk plus 15 % dried skim milk) with 1-5 % mono-diglyceride emulsifier and titanium dioxide. These ingredients were blended and homogenized, pasteurized, cooled and packed. The final product contained 0.2 % milk fat, 10 % protein, 10 % carbohydrate and 0.12 % sodium w/w (TS approx 10 %) and provides approx 10kcal /11ml serving.

A procedure was developed for the production of dairy whiteners that was rich in milk proteins and nearly free of lactose. The method utilized ultrafiltration with no pH adjustment and relatively low temperature. The micro structural studies of dairy whiteners revealed that the surface structure of the powder became smoother as lactose was reduced.

2.15. Quality Attributes

The sole purpose of coffee/ tea whitener is the development of a desirable color change in tea /coffee. In addition to this it should also impart body, mouth feel and flavor to the beverages or food to which it is added such as coffee/ tea or cereal dishes. Coffee/tea whitener may be in powdered, fluid or frozen form. There are two types of whiteners, dairy and non-dairy whiteners. Although basic requirements such as whitening ability, mouth feel and flavor development remain similar for both types of whiteners. However, Formulation and manufacture of these whiteners shall be widely different to make them stable in different forms. Good whiteners must have sufficient whitening power, emulsion stability and instant solubility in beverage or food for which it is especially formulated. For example coffee whiteners should have the ability to withstand the high temperature (80-90^{0}C) and low pH

(4.6 –5.2) of coffee solution. The emulsion stability of coffee whitener is also affected with ionic concentration of calcium coming from coffee and hard water (Early, 1990).

Organoleptic evaluation of coffee/ tea whitener (dried/fluid) must be done after adding into the beverage and looking for its ability to whiten and develop mouth feel and flavor. The development of any off-flavor and oiling–off /feathering may also be observed closely as objectionable changes.

2.16. Organoleptic Quality

Organoleptic Quality of the product is the most important from the consumer acceptance points of view. The perceivable sensory attributes viz. flavor which comprises taste and aroma, body and texture, color and appearance are the main deciding factors in food acceptance. Therefore, it is necessary to sensorily evaluate the product by a panel of trained Judges (Arora and Sharma, 1994). However, there is no single standardized process for sensory evaluation.

Thompson and Reniers (1982) reported overall acceptability scores of coffee whiteners as such that varied from 3.7 to 7.6 on a 9-point Hedonic scale. When coffee whiteners samples were evaluated in coffee, the average flavor score ranges from 3.9 to 7.2, appearance scores 2.6 to 7.2 and overall acceptability scores range from 2.7 to 6.6. Feathering was Judge subjectively on a 5 point scale with 0 = no feathering and 5 = extensive feathering. The scores obtained for different samples range from 0 to 4.

Arora and Sharma (1994) developed a 100 point score card for the evaluation of whiteners. The scorecard also included the type and intensity of defects in the products and weightage of score to a particular attributed were also included in the score card.

3. MATERIAL AND METHODS

This section deals with the materials and methods employed for the formulation of non-fat dairy whitener, analysis of its Physico-chemical properties, sensory qualities and statistical analysis of the data received during the study of this project.

3.1. Manufacture of non- fat dairy whitener

The following materials are required for manufacture of non-fat dairy whiteners.

3.1.1. Materials

3.1.1.1. Sweet cream buttermilk

Sweet cream buttermilk (Total solid, 5.75 –6.61% and fat 0.3 - 0.4%) was obtained from Experimental Dairy of this Institute.

3.1.1.2. Buffalo skim milk

Fresh Buffalo skim milk having fat % 0.1- 0.3 % and total solid in the range of 9.5 - 10.10% was obtained from Experimental Dairy.

3.1.1.3. Stabilizing Salts

Food grade of Dipotassium hydrogen phosphate (K_2HPO_4), Disodium hydrogen orthophosphate (Na_2HPO_4), Monosodium hydrogen phosphate and Trisodium citrate were obtained from Glaxo Laboratories India Ltd.Mumbai.

3.1.1.4. Sugar

Fresh sugar was procured from Karnal local market.

3.1.2. Ultrafiltration Plant

Fig.3.1. Ultrafiltration Plant

Ultrafiltration plant used for the preparation of ultrafiltered and diafiltered (UF) retentate is shown in Figure3.1 Pilot Ultrafiltration plant (Tech-Sep, France) with tubular module (channel diameter, 6 mm) having ZrO_2 membrane (membrane surface area, 1.68 m^2 and membrane molecular weight cut off, 50,000 Dalton) was used for the present investigation. The plant was fitted with tubular heater for controlling the temperature during Ultrafiltration operation, balance tank (Capacity, 200 liter), pressure gauges and temperature indicator. The inlet and outlet pressure of feed is usually kept at 4.6 kg/cm^2 (inlet) and 3.6 kg/cm^2 (outlet) at the retentate side and 1 kg/cm^2 (outlet) at the permeate side, respectively. The ultrafiltration plant was cleaned by combination of water flushing, hot alkali (NaOH) cleaning at 75^oC for 15 min. followed by flushing with hot water for 20 min. and acid (HNO_3) cleaning at 80^oC for 15 min with circulation at inlet and outlet pressure of 4.6 and 3.6 bars on the retentate side, respectively. The plant was said to be clean only when it regained its original H_2O flux.

3.1.2.1. Methods

3.1.2.1.1. Ultrafiltered buttermilk retentate

Raw cream, containing 40 % fat was obtained from Experimental Dairy and pasteurized at (80^0C for 16 sec), stored at 4^oC in SS tank for approximately 16 hrs. And then stirred vigorously at approx 140 rpm using butter churn until fat granules appeared; the granules were kneaded at approx 20 rpm to release the buttermilk. One liter of cream yielded approx 500 ml of buttermilk at 20^oC. Buttermilk approximately 150 to 180 kg having total solids in the range of 6.61-7.0% and fat from 0.2 - 0.5 were obtained and preheated to 40^0C t0 45^0C for clarification and separation in the cream separator.

The clarified SCBM were pasteurized at 80^0C for 16 sec and was transferred to the balance tank of UF plant after cooling to 50^oC. The flux rate and the quantity of permeate and retentate was measured at 5 minutes interval, during the whole operation of ultrafiltration and samples were collected at 2- fold, 3- fold and 4-fold concentration to determine heat stability and flavor and for Other analysis parameters. Ultrafiltration was carried out to a level of 22 - 24 % total solids as detected by Abbes Refracto meter and later on by gravimetric method.

3.1.2.1.2. Ultrafiltration of Buffalo Skim Milk

Pasteurized Buffalo skim milk, 120 Kg was collected from Experimental Dairy of the Institute and was transferred to the balance tank of UF plant after heating at 60 ^{O}C and cooling to 50^{O}C. The flux rate and the quantity of permeate and retentate was measured at 5 minutes interval, during the whole operation of ultrafiltration. Ultrafiltration was carried out to a level of 22 – 24 % total solids detected by Abbes Refractometer and later on by gravimetric method. The initial sample of stabilized buffalo skim milk, along with other samples of UF retentate having different TS levels were collected for the heat stability testing. About 2-liter of each sample at different TS level was collected

3.1.3. Heat Stability of retentate

A well-insulated and thermostatically controlled oil bath made from steel was used, which, has internal dimensions, length: 37.5 cm width: 32.0 cm and depth: 16.0 cm and was fitted with a 2 KW immersion heater horizontally at the base using neoprene gasket. The oil bath was fitted with a thermostat to control the temperature up to 250^{O}C and a mercury thermometer (0-250^{O}C) to check the temperature of oil. A fixed quantity of milk or UF-DF retentate (around 2 ml) was pipetted into corning glass tubes, having 4 ml capacity (10.5 cm length and 1.0 cm internal diameter). The tubes were then stoppered and clamped and held in the horizontal rack, which, could hold 24 tubes at a time and was immersed horizontally in the oil bath so that tubes containing samples get dipped into the oil up to the level of sample or milk in the tubes. The rotation caused the sample tubes to rock in a vertical plane about the center of the horizontal stand through an angle of about 40^{o} and caused the milk sample to flow gently, rocking mechanism was started when the tubes were placed in the oil bath.

3.1.3.1. HCT Determination

Heat stability of UF retentate of sweet cream buttermilk (SCBM), Buffalo skim milk and mixture of buffalo skim milk & SCBM in different proportion was measured by determining the time required for clots to appear at 130^{o}C. A well-insulated and thermostatically controlled oil bath was used for HCT determination. The temperature of the

oil bath was maintained at 130±1°C. The 2 ml samples of different UF retentates with or without stabilizers were taken in corning glass tubes of 4 ml capacity used for the HCT determination. These tubes were stopper and clamped and then held on a horizontal rack in the oil bath, about 24 sample tubes could be kept at a time and these were immersed horizontally in the oil. HCT of samples were determined at 130±1°C as per the procedure followed by Tayal and Sindhu, (1983). As soon as the moving particles or clots were observed in the different samples clotting time (min.) for a particular tube was recorded.

3.1.3.2. Studies on Improvement in Heat Stability of UF Retentate

Different types of stabilizers were used for the determination of heat stability of UF retentate. Dipotassium hydrogen phosphate, Monosodium and disodium phosphate, and trisodium citrate were added at the rate of 0.1, 0.3, 0.5, 0.7 and 0.9%, respectively.

3.1.4. Analytical Method

3.1.4.1. pH determination

The pH meter, PHAN LABINDIA Model (Labtek Engg. Pvt. Ltd., India). was used for the present investigation. The pH of the samples was measured by directly inserting glass electrode after standardizing the pH meter by pH 4, 7 and 9 buffer solutions. The pH of stabilized samples was determined with the help of pH meter fitted with a combination electrode. About 50 ml of samples was taken for pH determination. The electrodes assembly was calibrated with suitable standard buffers of pH 4.0, 7.0 and 9.0, respectively. UF retentate from sweet cream buttermilk (SCBM), Buffalo skim milk and mixture of SCBM and buffalo skim milk were analyzed for pH.

3.1.4.2. Fat

Fat content in BSM, SCBM and mixture of BSM added SCBM (1:2) UF retentates were determined by Gerber Method. (IS: SP: 18 (Part XI) - 2001)

3.1.4.3. Total solid

Total solid in BSM, SCBM. and BSM added SCBM (1:2) UF retentates were estimated by Gravimetric method as follows: (IS: SP: 18 (Part XI) - 2001)

- Weighed accurately clean and dry empty dish.
- Added 5 gm sample in the dish and weighed it again accurately.
- Put the all dishes in the oven at 100± 2^{o}C temperatures for 3 hrs.
- After drying the samples in the oven, kept it into a desiccator for cooling up to 30 min.
- After cooling weighed it.
- Now calculated the percentage of total solids in the samples by following formula

$$\% \text{ total solid in milk } = \frac{(W_3 - W_1)}{(W_2 - W_1)} \times 100$$

Where W1 = Wt of empty dish

W2 = Wt of empty dish + wt of sample

W3 = Wt of dish + Wt of sample after drying

3.1.4.4. Ash

The ash content of milk and retentate was estimated by the method given in (IS: SP: 18 (Part XI) - 2001)

About 5g samples were taken in a silica crucible and incinerated it on a heater till smoke free. The contents of the crucible are ignited at 550^{0}C in a muffle furnace for 3- 4 hours and cooled for 30 minutes in a desiccator.

$$\% \text{ ash } = \frac{\text{Loss of weight}}{\text{Weight of sample}} \times 100$$

3.1.4.5. Protein

The protein content of milk and retentate was determined by semi-micro Kjeldahl method described by Manfee and Overman (1940) using Kjeltec automatic digestion and distillation equipment (2300, Kjeltec Analyzer, Make FOSS) as follows.

3.1.4.5.1. Digestion

About 0.5 to 1 gm of sample was taken in a digestion tube and added 10 ml of conc. H_2SO_4 and add approx 1.0 gm digestion mixture containing Na_2So_4 and CuSo4 in the ratio of 50:1. Now digestion tubes were kept at 400^oC for 2-3 hour.

3.1.4.5.2. Distillation

Make up the volume of the digested sample in 100 ml volumetric flask with distilled water. 10 ml of this sample was taken in to 500 ml digestion tube, which is attached to the distillation assembly slowly from the top of distillation assemble automatically, add 15 ml of 40 % NaOH. Start the steam automatically to the collection of distillate in a 100 ml conical flask containing 25 ml (4 % solution) of saturated boric acid with one or two drops of mixed indicator.

3.1.4.5.3. Titration

Titrated this distillate by Kjeltec analyzer after sufficient quantity has been collected (60-70 ml) against N/50 HCl. After 240 sec (complete distillation time), take reading to the sample.

$$\% \text{ protein} = \frac{V \times 0.028 \times 6.38}{W} \times 100$$

$$= \frac{0.18v}{W}$$

Where,

V = Titre volume of N/50 HCl used (ml)

W = Weight of sample (g)

3.1.4.6. Lactose

Lactose content of samples was determined by subtracting protein and ash from total solids.

% Lactose = %Total solid - (%Protein + %Ash + %Fat)

3.1.4.7. Calcium

Amount of calcium in milk and UF retentate samples were determined by method described by Davis and White, (1962). Take 2-3 g of the sample in a silica crucible. Incinerated the sample on the hot plate till smoke free. Transfered the crucible in a muffle furnace maintained at $550^{o}C \pm 10^{o}C$ for 3-4 hour till the residue becomes carbon free. Allowed to cool and dissolve the residue in dilute HCl (1:4). Transfered it quantitatively in 100 ml volumetric flask. Added some more dilute HCl to dissolve and transfer to the flask and make up the volume to 100 ml with distilled water. Taken 25 ml of the HCl extract into 250 ml beaker and add a piece of red litmus paper. Added NH4OH till the liquid in the beaker is alkaline and then slight excess. Bring the content of beaker to boil. Added 10 ml of saturated ammonium oxalate solution. Continue boiling over a low flame for 10-15 minutes, covering the beaker with a watch glass, to render the precipitate granular. Leave for at least 2 hours, preferably over night. Decant the supernatant liquid through a whatman No-42 filter paper, leaving much of the precipitate in the beaker. Washed a number of times with hot water. Finally transferred all the precipitate on the filter and continue washing with hot water till free of oxalates (test- Collect 5 ml of filterate in the test tube, added 3-4 drops of dilute H_2SO_4 (1:4) and 1 drop of N/10 $KMnO_4$, keep to boil, if the colour remains pink, washing is completed). Placed the beaker in which the calcium precipitation was done below the funnel. Pierced the filter paper with a glass rod and wash down the precipitate into the beaker by a jet of hot water (about 40 ml). Add 10 ml of dilute H_2SO_4 (1:4) to the beaker. Heat the content of the beaker to about $90\text{-}95^{0}C$ and titrated against N/10 $KMnO_4$. On reaching end point add the filter paper (on the funnel) into the beaker and completed the titration to a faint permanent pink color.

$$\%\text{Calcium} = \frac{20 \times Vx \times 100 \times 100}{1000 \times 10 \times 20 \times W} = V/W$$

Where, V = Volume of N/10 $KMnO_4$ used for titration (ml)

W = Weight of the sample taken (g)

3.1.5. Analysis of Physico chemical properties of liquid dairy whitener

3.1.5.1. Whitening ability

A Tristimulus spectrophotometer Hunter Lab model Colour Flex® (Hunter Associates Laboratory Inc., VA, U.S.A.) was used to measure the color of the sample. The instrument was standardized in day light at reflectance angle10^0. The instrument was calibrated with white and black tile. Measurements were then made on the sample taken in a glass sample cup supplied with the instrument by filling it to a fixed level for each sample. Color was recorded using the CIE-L^* a^* b^* uniform colour space (CIE-Lab), where, L^* indicates lightness, a^* indicates hue on a green (-) to red (+) axis, and b^* indicates hue on a blue (-) to yellow (+) axis.

3.1.5.2. Hardness of water

Hardness in coffee/tea solution is an important factor influencing the feathering resistance of whiteners in coffee/tea. For determination of total hardness of water, 100 ml of water was taken in a 250 ml of flask. Then added 2 ml of ammonium buffer solution (NH_4Cl/ NH_4OH, pH 10) and add 3 drops of indicators (freshly prepared eriochrome black T indicator) and then titrated against 0.01M EDTA solutions until color changes from violet to blue. That titre value was noted and hardness calculated in ppm. The hardness of water used for coffee/tea preparation was found to be, on average 262 ppm.

Hardness = titre volume multiplied by ten

3.1.6. Sensory Evaluation

The liquid non-fat dairy whitener, prepared from SCBM and buffalo skim milk admixing was compared with control (Amulya Dairy Whitener, Amul). Samples were subjected to sensory evaluation on a 9 point Hedonic scale (Fig. 3.3) by a panel of 8 judges selected from the DT Division. These products were also subjected to sensory evaluation i.e., flavor, whitening ability, appearance (Feathering and Oiling off) and mouth feel after adding to coffee /tea solution at 60^{o}C- 70^{o}C.

Standard coffee solution was prepared by heating 1800 ml cold tape water to 80^{0}C and added 15 g of Nescafe coffee reported by Gruetzmacher and Bradley (1991). The 7% sugar and 3% formulated non-fat dairy whitener solid on total solid basis was added with medium stirring.

The tea liquor was prepared by the method described by Hui (2004) except that instead of 2%, 1.6% Tata tea was used in boiling water. Tea liquor was taken in a stainless steel vessel. Add 7% sugar and 3% formulated non-fat dairy whitener on total solid basis and boiled on an electric heater for 3-5 min with medium stirring. The tea mixture was then passing through wire mesh to filter the tea.

3.1.7. Statistical Analysis

Data obtained during the present investigation of the project work were subjected to statistical analysis described by Snedecor & Cocharan (1994) by using randomized block design.

SENSORY SCORE CARD

Product: Dairy whitener

You are requested to assess the product in-terms of general acceptability on a 9 point Hedonic scale.

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

CHARACTERISTIC	Sample No				
	1	2	3	4	5
Flavor					

Remarks, if any

Signature

Dated: _____

SENSORY SCORE CARD

Product: Coffee/Tea

You are requested to assess the product in-terms of general acceptability on a 9 point Hedonic scale.

Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither liked nor disliked	5
Disliked slightly	4
Disliked moderately	3
Disliked very much	2
Disliked extremely	1

CHARACTERISTICS	Sample No				
	1	2	3	4	5
Flavor					
Mouthfeel					
Whiteness					
Appearance					
(Feathering & oiling off)					
Sweetness					
Over acceptability					

Remarks, if any

Signature

Dated: _____

4. Results and Discussion

This project was undertaken to formulate a good quality non-fat dairy whitener using UF buttermilk retentate as a base. Sweet cream buttermilk was concentrated by pilot ultrafiltration plant using ceramic membrane. The retentate was analyzed for gross chemical composition. For improving flavor of SCBM retentate, buffalo skim milk retentate was added to it. The buffalo skim milk added SCBM UF retentates were evaluated by a panel of judges for sensory parameters on 9-point Hedonic scale. Salt addition for flavor improvement was also tried. Heat stability of buttermilk retentate and skim milk retentate was investigated separately and also with BSM added SCBM UF retentates. Effect of different stabilizing salts was studied to find out the best stabilizer suitable for increasing the stability of the retentates. Effect of sugar on heat stability with the optimized proportion was also studied. Finally liquid non-fat dairy whitener was formulated and compared organoleptically with Market sample in tea/coffee. Results obtained during this investigation have been presented and discussed hereunder.

4.1. Gross chemical composition of commercial Sweet cream buttermilk

The gross chemical composition of sweet cream buttermilk (SCBM) obtained from Experimental Dairy is given in Table 4.1.

Table 4.1. Chemical composition of commercial sweet cream buttermilk

Constituents	SCBM
TS (%)	5.75 - 6.61
Fat (%)	0.2 - 0.40
Protein (%)	2.23 – 2.65
Lactose (%)	3.02 - 3.17
Ash (%)	0.30 - 0.39

4.2. UF CONCENTRATION OF SWEET CREAM BUTTERMILK

4.2.1. Permeation behavior of SCBM during ultrafiltration

Fig. 4.1 shows the permeation behavior of ceramic membranes during ultrafiltration of Sweet cream buttermilk. As the solids concentration in the retentate increased, there was a steady decreased in the flux rate from 99.28 to 11.42 lit/m^2/hr after 80.83% volume reduction. This is because of the fact that as the feed concentrated with the advancement of ultrafiltration process, more or more proteins and salts get transported towards the surface of the membranes, this results is an increased thickness and resistance of the deposits on the membranes cause decline in the permeate flux. After 60.14% volume reduction the flux rate decline tremendously so further UF concentration would have been uneconomical. The membranes also got heavily fouled at higher concentration.

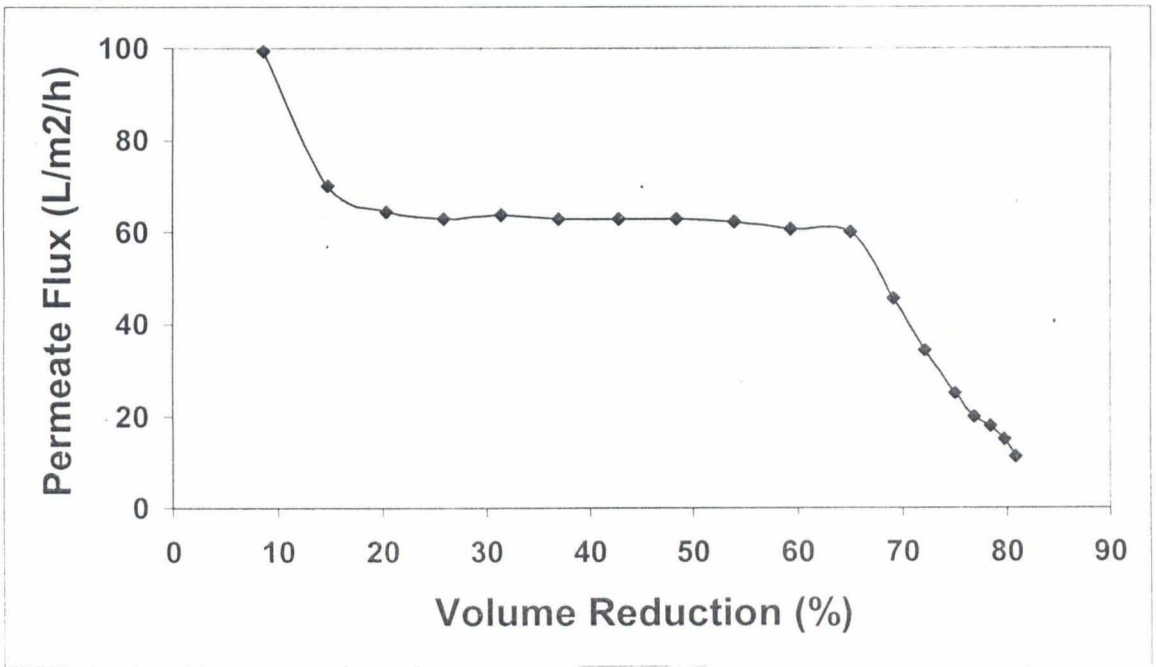

Fig. 4.1. Changes in permeate flux during ultrafiltration of sweet cream buttermilk

Similar observations were reported by Patel *et al.* (1992), Patel and Renter (1985) and Lawrence (1989) during ultrafiltration of buffalo and cow milk. Kessler (1981) also observed that permeate rate is inversely proportional to the deposit resistance and deposit resistance is directly proportional to the viscosity of the retentate. No such report on flux rate of SCBM is available for comparison.

4.2.2. UF Concentration of Sweet cream buttermilk

Sweet cream buttermilk was concentrated by ultrafiltration upto 5.2 fold concentration using ceramic membrane. At this level the permeate flux rate was too low, so further UF concentration would have been uneconomical. The membranes also got heavily fouled at higher concentration. The gross chemical composition of retentates is presented in Table 4.2. The total solid contents of SCBM retentates were 6.61, 10.12, 12.38, 16.27 and 21.61 for control, 1.76- fold, 2.87- fold, 4.04- fold and 5.2- fold UF concentration, respectively. Protein content increased from 2.65 to 15.21%, fat from 0.4 to 2.75%, and ash from 0.39 to 1.40%. Lactose concentration of SCBM was reduced from 3.17 to 2.25%.

Table 4.2. Chemical composition of UF concentration of sweet cream buttermilk retentates

Concentration level	Total solids (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)
1- fold	6.61	0.4	2.65	3.17	0.39
1.76 - fold	10.12	0.7	5.86	2.95	0.61
2.87 -fold	12.38	1.2	7.81	2.61	0.76
4.04 -fold	16.27	1.8	10.97	2.47	1.03
5.2 -fold	21.61	2.75	15.21	2.25	1.40

4.2.3. Sensory evaluation of SCBM retentates at different UF concentration

The different concentration of SCBM retentate was evaluated for flavor score and data obtained was presented in Fig 4.2. The flavor scores of 1.76-fold, 2.87-fold, 4.04 and

5.2-folds sample were found 5.41, 6.14, 5.81, and 5.25, respectively. The highest score (6.14) of 2.87-fold and lowest score 5.25 of 5.2-fold sample. The difference in flavor score of different folds of SCBM retentate was highly significant. The maximum score may be due to optimum level of TS in SCBM retentate and minimum score is due to high TS level in SCBM retentate and low content of lactose and salt.

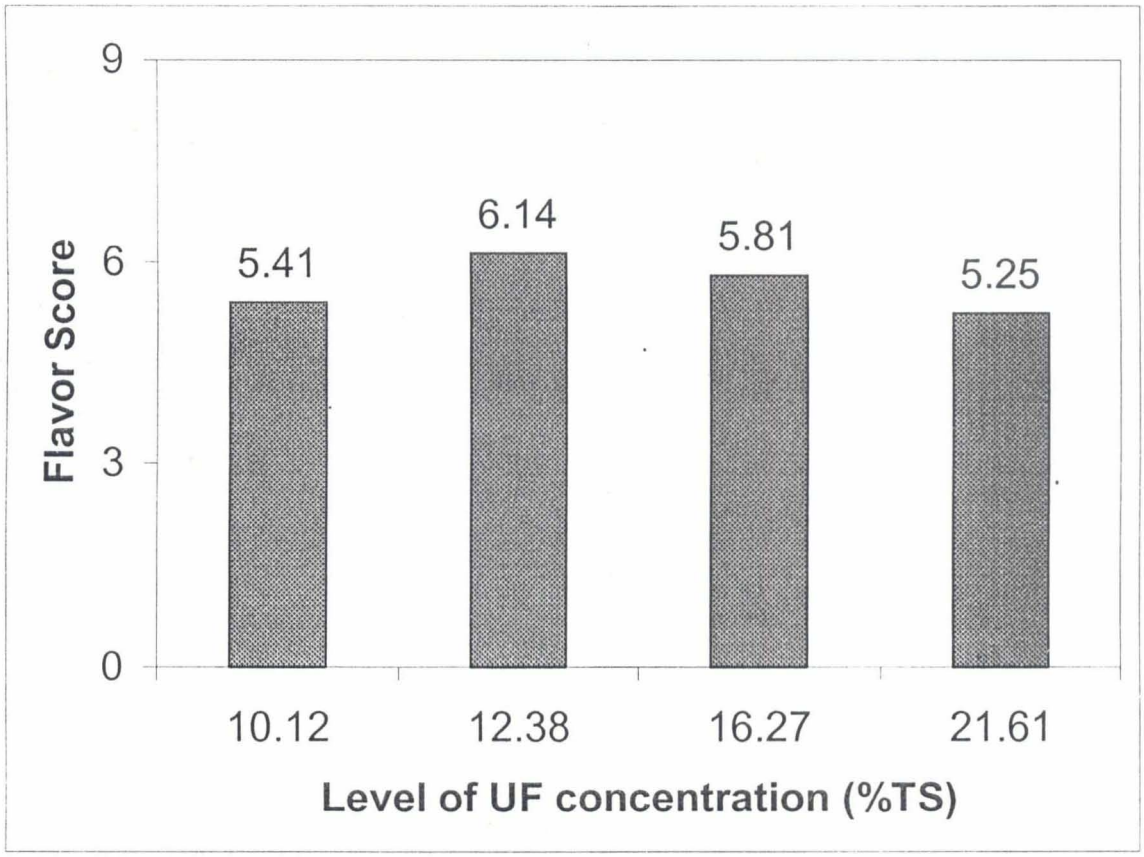

Fig. 4.2. Flavor score of different UF concentration of retentates made from SCBM

4.2.4. Heat stability of different UF concentration of sweet cream buttermilk

The heat stability of milk, especially of the caseinate system, to high heat treatment is of great importance to the dairy product manufacturers, especially in the manufacture of sterilized concentrated milk.

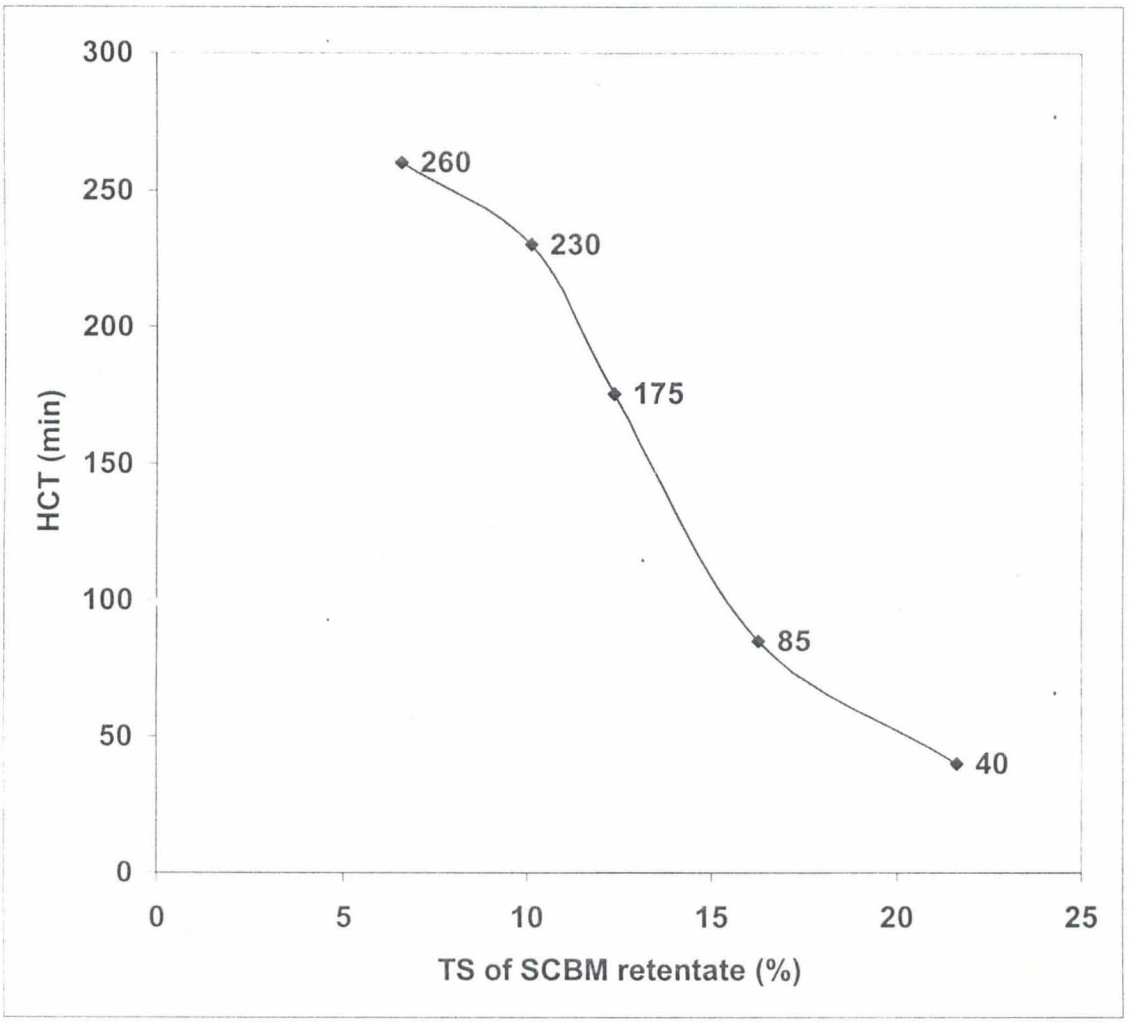

Fig. 4.3. Effect of different level of UF concentration of SCBM on heat coagulation time

Therefore, improvement in heat stability of different concentration of UF sweet cream buttermilk is essential. Heat stability of different concentration of UF retentate obtained from SCBM is presented in Fig. 4.3. The pH of the retentates obtained from UF plant were 6.95, 6.90,6.87, 6.86, and 6.84 for control, 1.76- fold, 2.87- fold, 4.04- fold, and 5.2- fold,

respectively were shown in Fig. 4.4. Result shows that as the concentration level of SCBM increased during UF, there is decreased in pH, as a result heat stability decreased progressively due to passing of mineral into the permeate and most of the protein being retain in the concentrate. Sindhu (1995) reported that decline in heat stability due to decrease in the pH of the concentrate. SCBM has maximum heat stability at pH 6.95 and TS 6.61 while; 5.2-fold SCBM retentate had minimum heat stability (40 min) at pH 6.84 and TS 21.61%. Singh *et al.* (1995) also reported that as the concentration level increased the heat coagulation time (HCT) decreased during ultrafiltration of milk.

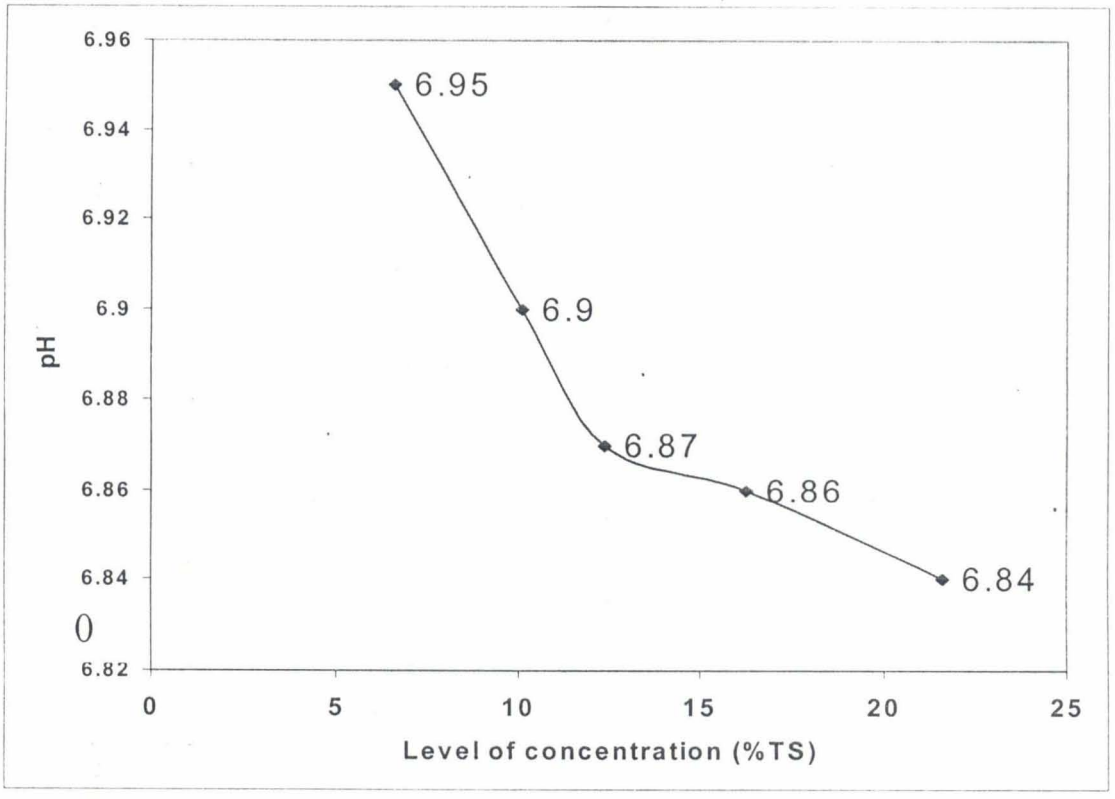

Fig. 4.4. Effect of different level of UF concentration of SCBM on pH

4.2.5. Effect of different stabilizers on the pH and heat stability of UF concentration of SCBM retentates

The effect of different stabilizers namely Trisodium citrate, mixture of Monosodium phosphate and Disodium phosphate (2:1) and Dipotassium hydrogen phosphate are shown in Fig. 4.5 and Fig. 4.6. The addition of different levels of trisodium citrate to SCBM (5.2-fold) UF retentate tremendously decreased the heat stability. This may partly be due to significant increase in pH from 7.18 to 7.48, because high heat stability of buttermilk is in the pH range of the minimum of type A milk (pH 6.8 to 7.0). O'Connell and Fox (2000) also reported maximum heat stability in the pH range of 6.8–7.0. Sindhu and Tayal (1984) also reported that addition of trisodium citrate caused a significant increase in pH of fluid milk

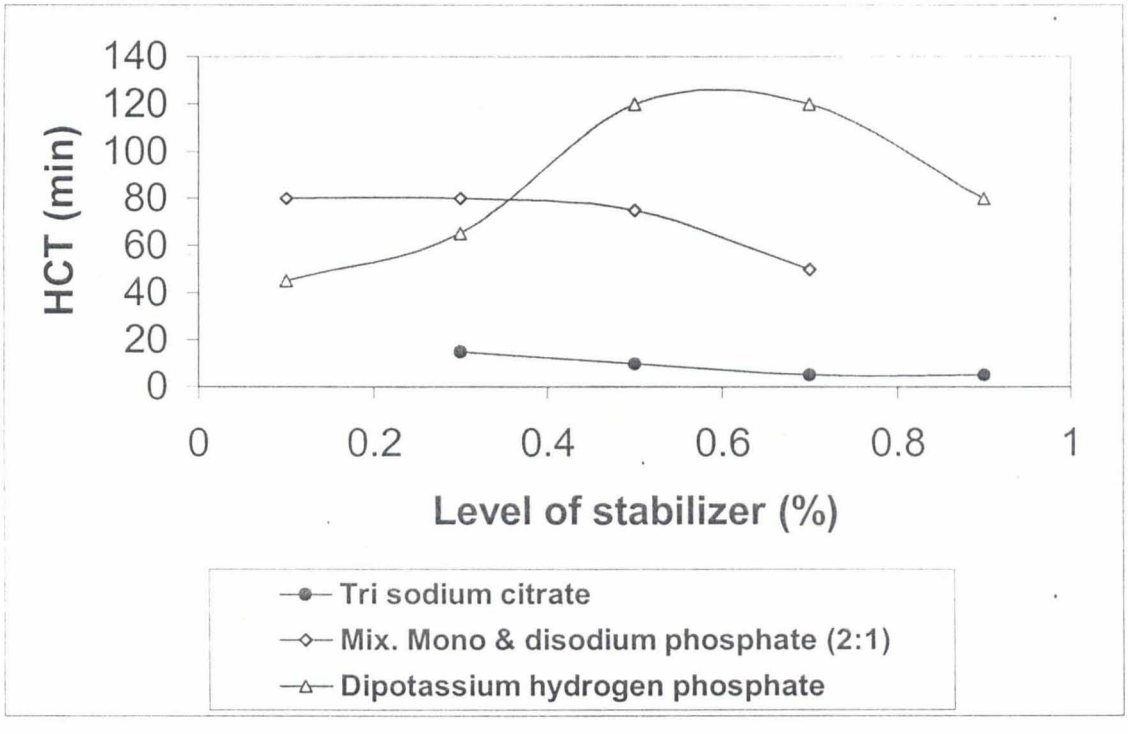

Fig. 4.5. Effect of different stabilizers on the HCT (at 130°C) of 5.2-fold UF (TS 21.61%) SCBM retentate

The addition of Monosodium and Disodium phosphate mixture (2:1 w/w) on the HCT pH profile of UF concentrated SCBM retentate indicates that as the level of concentration (0 –0.7%) increased the pH decreased from 6.90–6.58 and hence heat stability of UF concentrated SCBM increased upto pH 6.78 and then start to decrease by addition of 0.5% Monosodium and Disodium phosphate mixture (2:1 w/ w). The addition of Dipotassium hydrogen phosphate (0.1–0.9%) to SCBM retentate tremendously increased the heat stability upto 0.7% level and then decreased. Maximum heat stability of UF SCBM retentate was in the pH range 7.06 to 7.15 at the concentration level 0.5-0.7%.

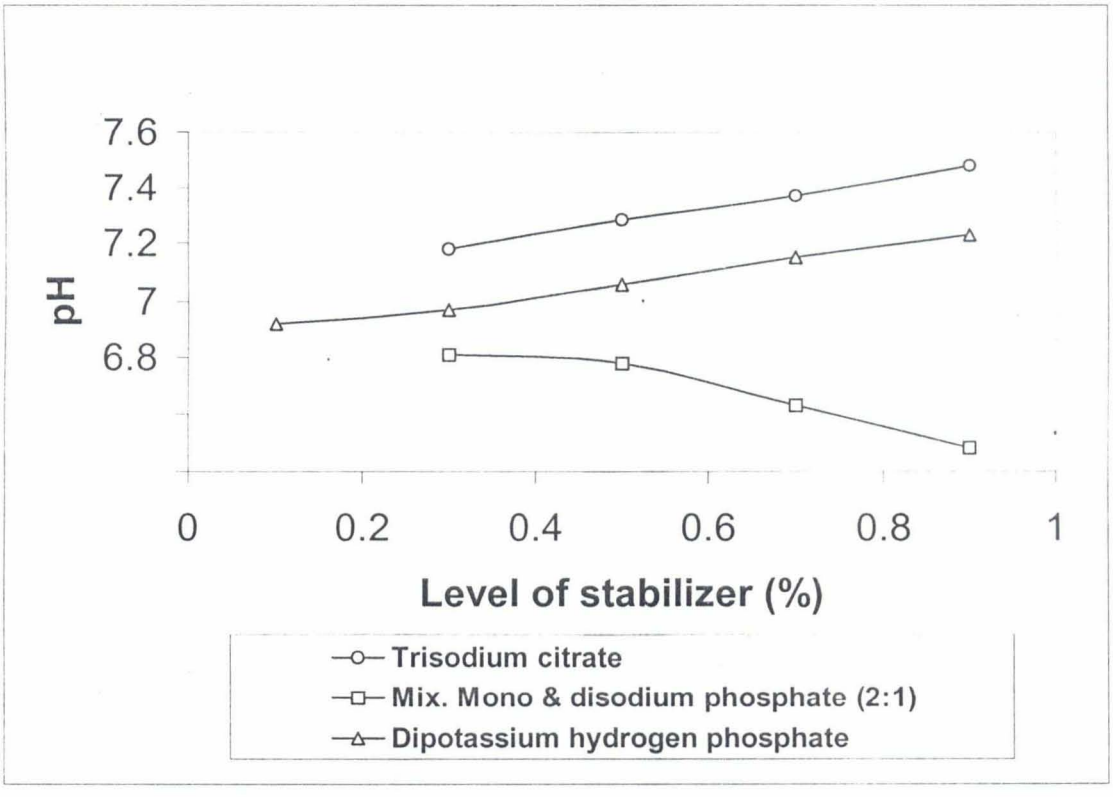

Fig. 4.6. Effect of different stabilizers on pH of UF (TS 21.61%) 5.2-fold SCBM retentate

When we compare between mixture of Monosodium and Disodium phosphate (2:1 w/w) and Dipotassium hydrogen phosphate, the mixture of Monosodium and Disodium phosphate (2:1 w/w) increased heat stability two times at the level of 0.1–0.3%, whereas Dipotassium hydrogen phosphate increased 3.0 times at the level of 0.5–0.7%. Thus, we can

conclude that Dipotassium hydrogen phosphate is more effective to increase the heat stability of SCBM retentate.

4.2.6. Sensory evaluation of different UF concentration of SCBM retentate in Tea

The different UF concentrations of SCBM retentate were evaluated for sensory by a panel of judges on 9-point Hedonic scale and data obtained are presented in Fig 4.7. The Fig.4.7 indicates that flavor and mouthfeel score of different folds of SCBM retentate are lower side on 9-point Hedonic scale, because 100% SCBM retentate imparts its own flavor in tea. Therefore to improve the flavor and mouth feel, buffalo skim milk retentate was added in different proportion to SCBM retentate and evaluated in tea.

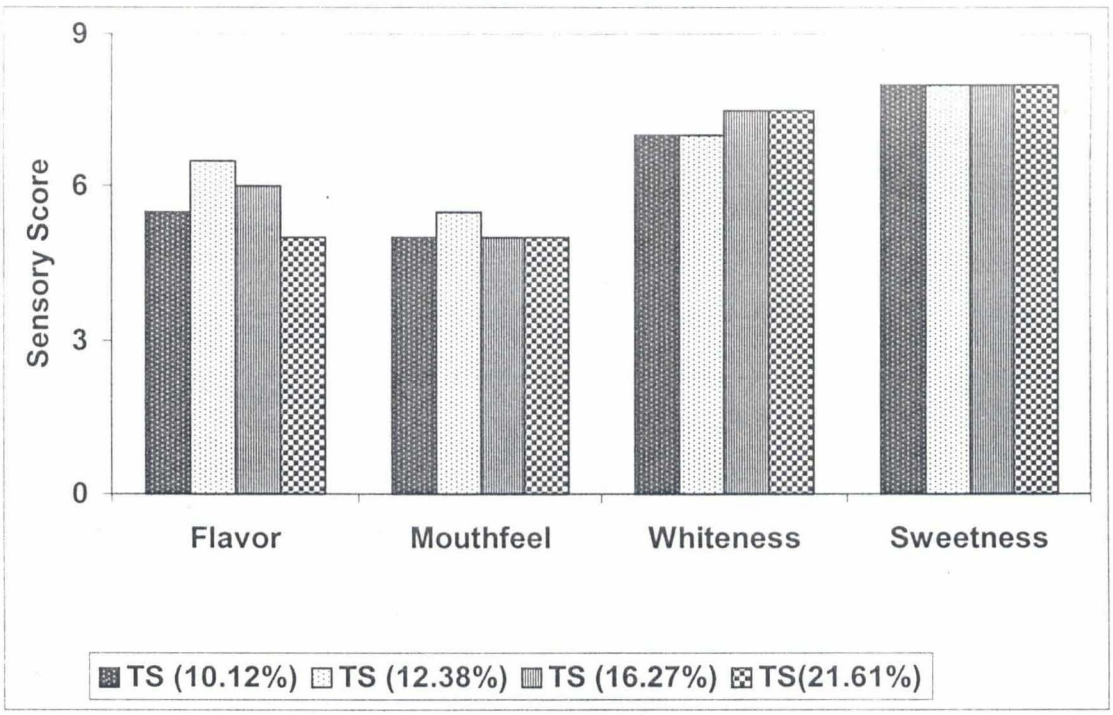

Fig. 4.7. Sensory score of different UF concentration of retentates made from SCBM in Tea

4.2.7. Heat stability of SCBM retentate, buffalo skim milk retentate and buffalo skim milk retentate admixed SCBM retentates

Heat stability of SCBM retentate, skim milk retentate and different proportion of skim milk retentate with SCBM retentate are presented in Table 4.3. Table 4.3 indicates that heat stability of buttermilk retentate is more comparison to skim milk retentate, this may partly be due to less TS content of buttermilk retentate and partly be due to low calcium concentration in buttermilk. Jenness and Patton proposed that the low calcium content of buttermilk might be due to breaking the oil-in-water emulsion during the preparation of buttermilk and release of free fatty acids into the aqueous phase, which complexes with calcium to form insoluble salts. O'Connell and Fox (2000) have reported similar observations during heat stability of buttermilk. As the proportion of SCBM retentate increased in buffalo skim milk retentate, the heat stability of blends increased.

Table 4.3. Heat stability of SCBM retentate; skim milk retentate and skim milk retentate admixed SCBM retentates

Type of Retentate	pH	Time (HCT)
Buttermilk retentate	6.83	50 min
Skim milk retentate	6.81	30 min
BMR: SMR (1:1)	6.82	40 min
BMR: SMR (2:1)	6.82	45 min
BMR: SMR (3:1)	6.83	50 min

BMR-Buttermilk retentate (4-Fold, TS-23.41)

SMR-Skim milk retentate (4-Fold, TS-25.76)

4.2.8. Flavor score of different UF retentates made from admixing BSM retentate to SCBM retentate

The retentate obtained from admixing of buffalo skim milk retentate (4.56-fold) to SCBM retentate (4.04-fold) indicates that admixing of BSM retentate to SCBM retentate in the ratio of (1:2) having slightly lower sensory score (6.5) then the (2:1) proportion (7.0) shown in Fig. 4.8. Therefore in formulation of non-fat dairy whitener the proportion (1:2 on total solid basis) of buffalo skim milk and sweet cream buttermilk was selected for further study, so as to utilize maximum quantity of buttermilk in the formulation of dairy whitener. SCBM having more MFGM consisting 55% protein, 44% lipid and small amount of carbohydrate reported by Kanno, (1989) rich in phospholipids, which imparts creamry mouth feel and softer texture in non- fat dairy whitener

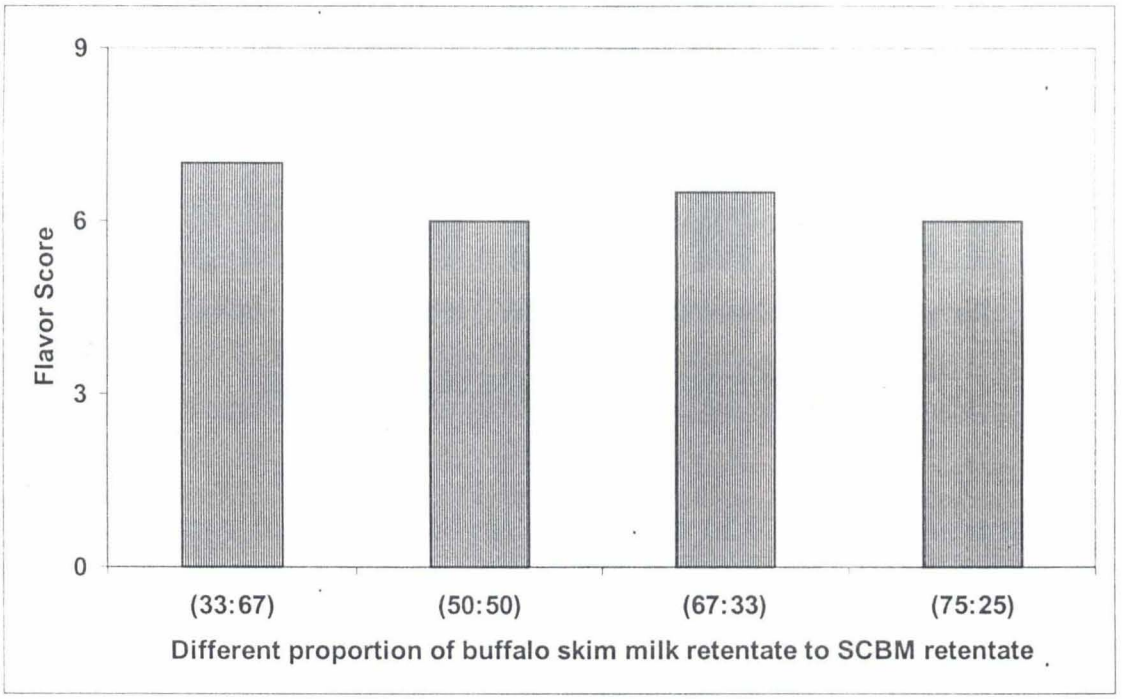

Fig. 4.8. Flavor score of different UF concentration retentates made from admixing of buffalo skim milk retentate to SCBM retentate

4.2.9. Sensory score of different UF retentates made from admixing of BSM retentate to SCBM retentate in Tea

The retentates obtained from admixing of BSM retentate and SCBM retentate were evaluated for sensory parameters in tea. The results indicate that when this retentate was used in tea sample than sensory score further increased due to masking effect of tea/coffee shown in Fig.4.9.

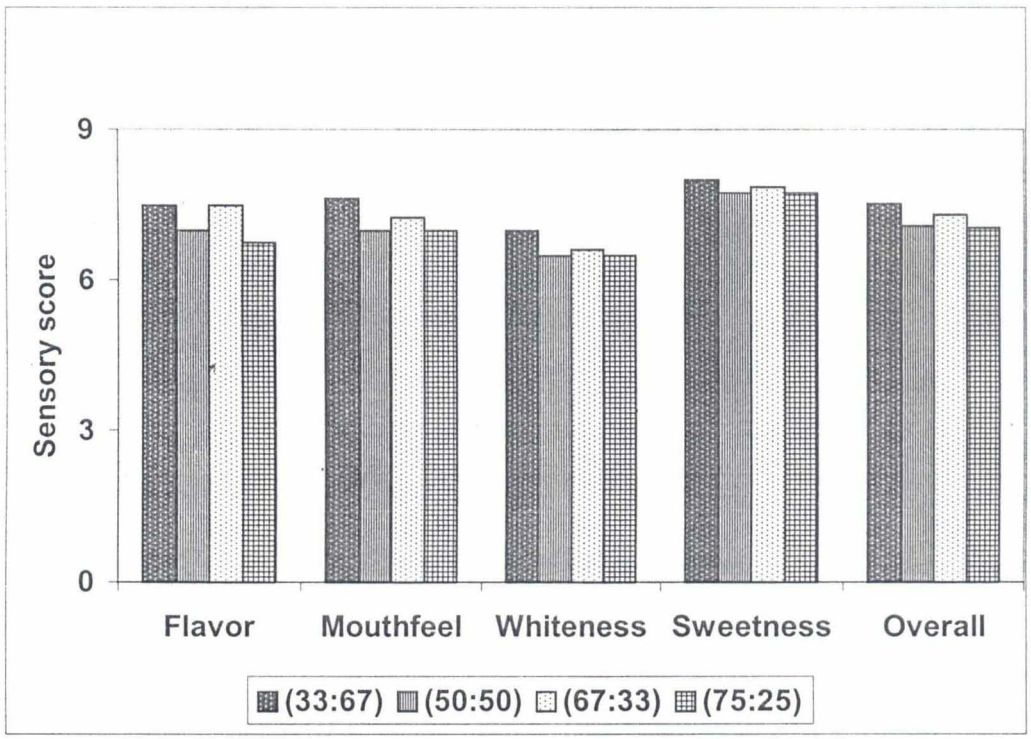

Fig 4.9. Sensory score of different proportion of UF retentates made from admixing of buffalo skim milk retentate to SCBM retentate in Tea

4.2.10. Changes in the permeate flux rate during UF concentration of blends of BSM to SCBM (1:2)

Fig. 4.10. Shows the performance of the ceramic membranes during ultrafiltration of BSM added SCBM in proportion (1:2) blend. As the solids concentration in the retentate increased, there was a steady decreased in the flux rate. This is because of the fact that as the

feed concentrated with the advancement of ultrafiltration process, more or more proteins and salts get transported towards the surface of the membranes, this results is an increased thickness and resistance of the deposits on the membranes cause decline in permeate flux. After 52.97% volume reduction the flux rate decline tremendously so further UF concentration would have been uneconomical. Similar observation was reported by Patel *et al* (1992) during ultrafiltration of cow and buffalo milk. No such report on flux rate of SCBM and buffalo skim milk blend is available for comparison.

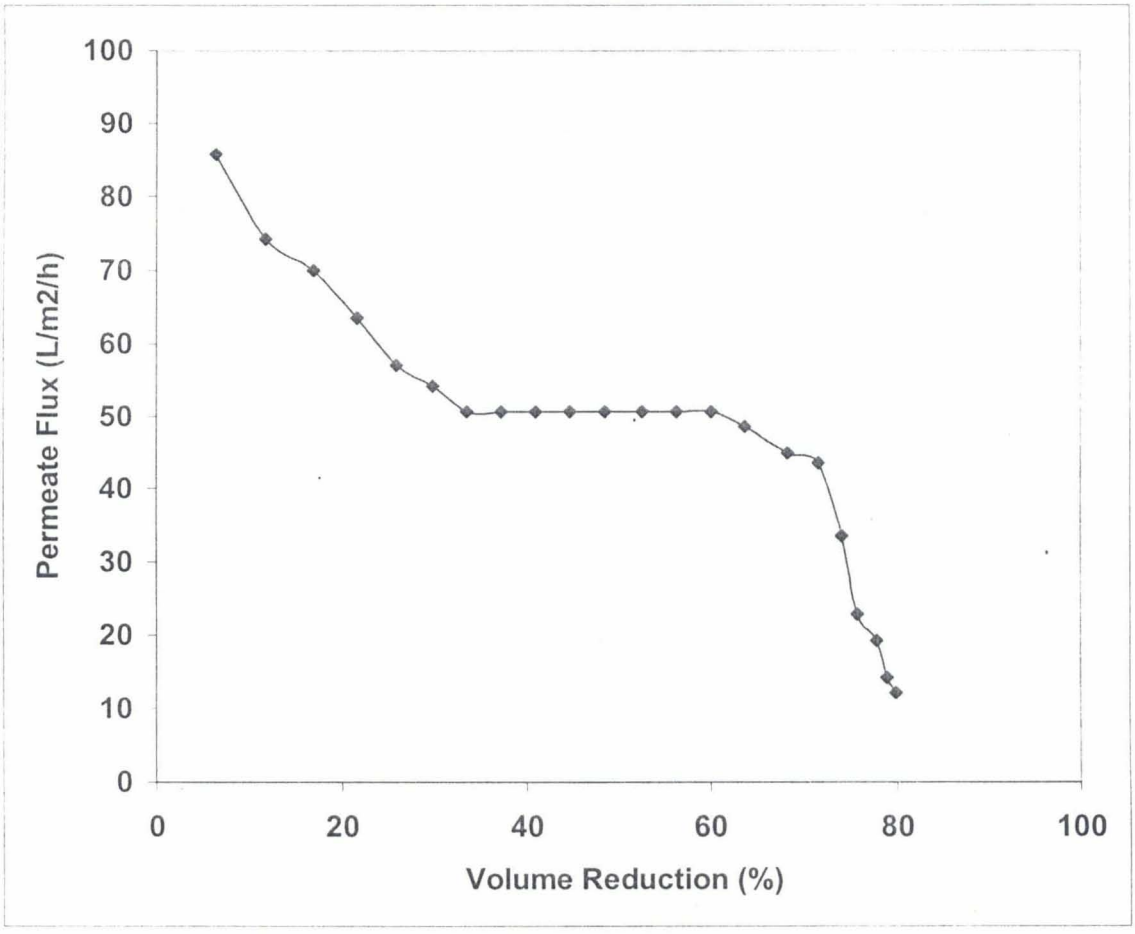

Fig. 4.10. Changes in the permeate flux rate during UF concentration of BSM to SCBM (1:2) blend

4.2.11. Gross chemical composition of retentates made from admixing of BSM to SCBM (1:2)

Buffalo skim milk added sweet cream buttermilk blends (1:2) were concentrated by ultrafiltration upto 5.06– fold concentration. At this level, the permeate flux rate was too low so that further UF concentration would have been uneconomical. Further, the membranes also got heavily fouled at higher concentration so that it was very difficult to clean them. The gross chemical compositions of retentates are presented in Table 4.4. The total solid content of different folds of retentate obtained from admixing of buffalo skim milk and sweet cream buttermilk (1:2) blends were 7.03, 11.72, 16.58, 21.60 and 25.04 for control, 2.12-fold, 3.20-fold, 4.56-fold and 5.06-fold, respectively. The protein content increased from 3.01to19.09%, Fat from 0.15 to 1.20% and lactose reduced from 3.42 to2.60%, respectively.

Table 4.4. Chemical composition of retentates made from admixing BSM to SCBM (1:2)

Concentration level	Total solids (%)	Fat (%)	Protein (%)	Lactose (%)	Ash (%)
1- fold	7.03	0.15	3.01	3.42	0.45
2.12 - fold	11.72	0.30	7.17	3.20	1.05
3.20 -fold	16.58	0.60	11.45	2.94	1.59
4.56- fold	21.60	0.80	16.13	2.75	1.92
5.06 -fold	25.04	1.20	19.09	2.60	2.15

4.2.12. Flavor score of different UF concentration of retentates made from admixing BSM to SCBM (1:2)

The flavor score of different retentates of TS 11.72, 16.58, 21.60 and 25.04% were 7.21, 7.78, 7.07 and 6.64, respectively shown in Fig.4.11.

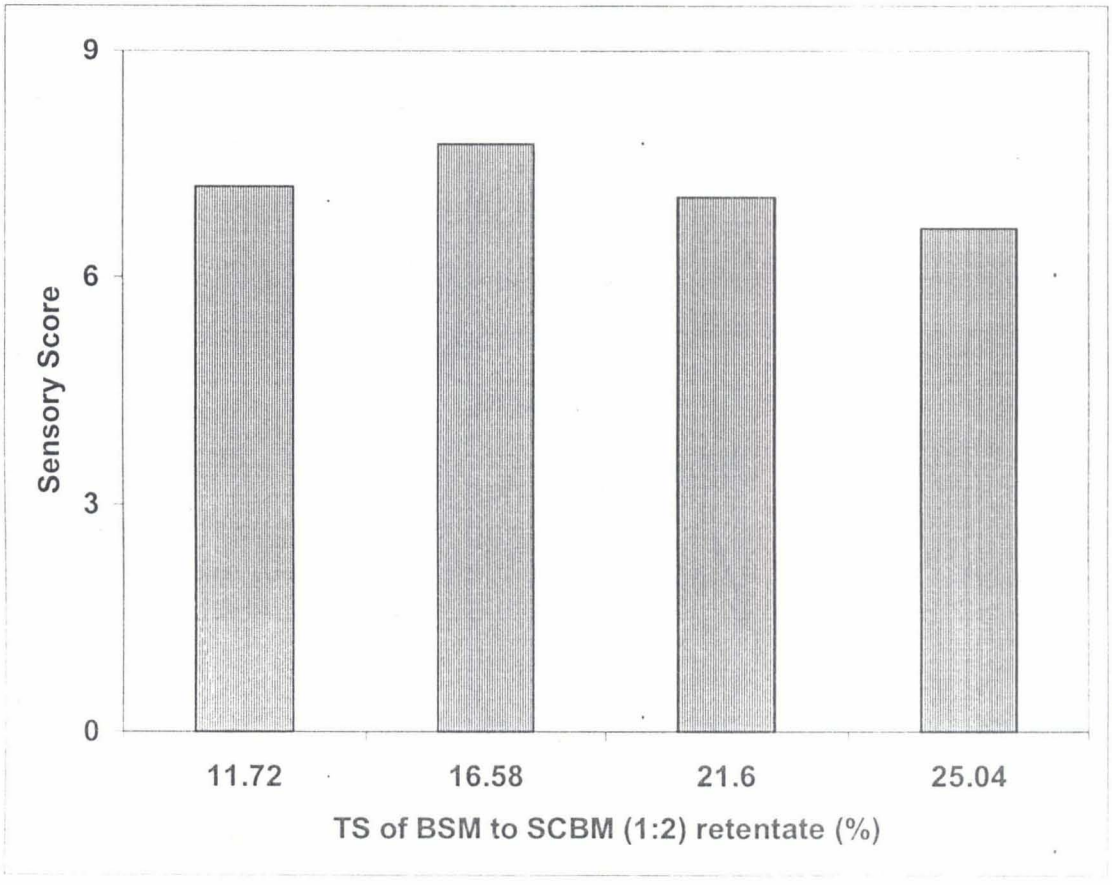

Fig. 4.11. Flavor score of different UF concentration retentates made from admixing of BSM to SCBM (1:2)

The highest score (7.78) of sample containing 16.68% TS and lowest score (6.64) of sample containing 25.04% TS. The highest score is due to optimum level of TS and lowest score is due to high total solid and less lactose content in the retentate. This figure clearly indicates that flavor score significantly increased on addition of buffalo skim milk in different concentration of UF retentates.

4.2.13. Heat stability & pH of different UF retentates made from admixing BSM to SCBM (1:2)

Heat stability & pH of BSM added SCBM (1:2) UF retentates are presented in Fig. 4.12 & Fig. 4.13. The pH of the retentates obtained from UF plant were 6.89, 6.83, 6.82, 6.77 and 6.70 for 2.12- fold, 3.20- fold, 4.56- fold and 5.06- fold, respectively. Result shows that

as the concentration level of retentates increased, the pH of its retentate decreased. At total solid level 7.03 the heat stability of blend is maximum (4hr). As the TS % increased in the retentates the heat stability decreased and it is minimum (5 min) at total solid level 25.04%.

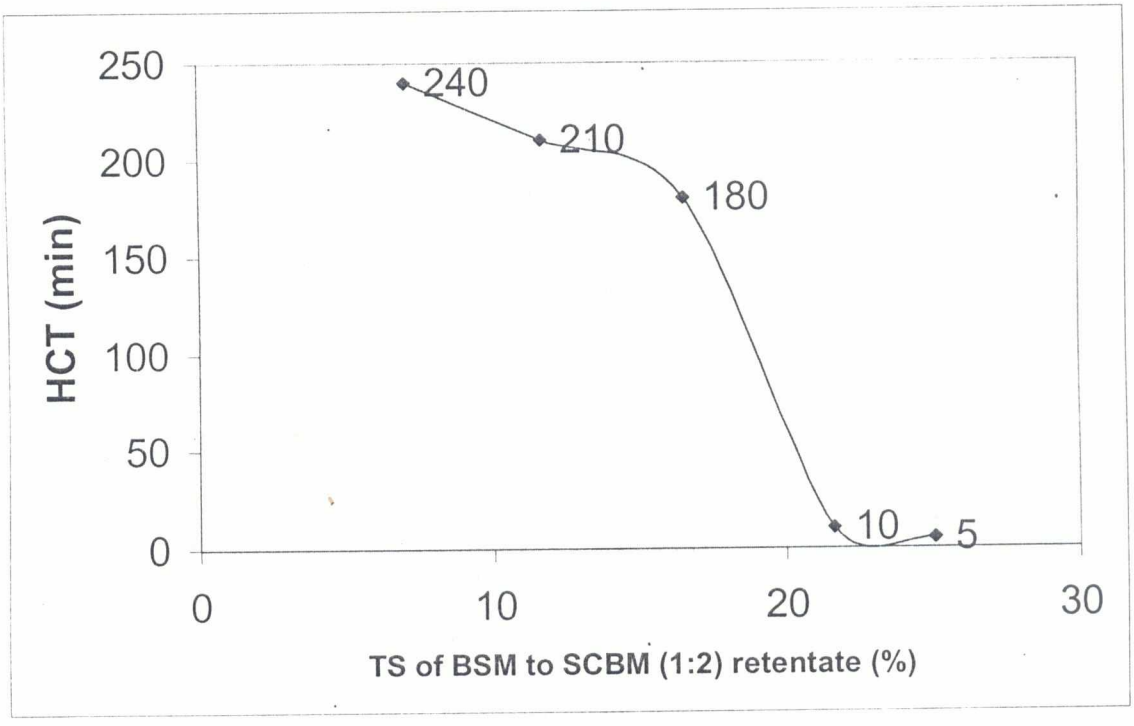

Fig. 4.12. Effect of UF concentration on HCT of retentates made from admixing BSM to SCBM (1:2)

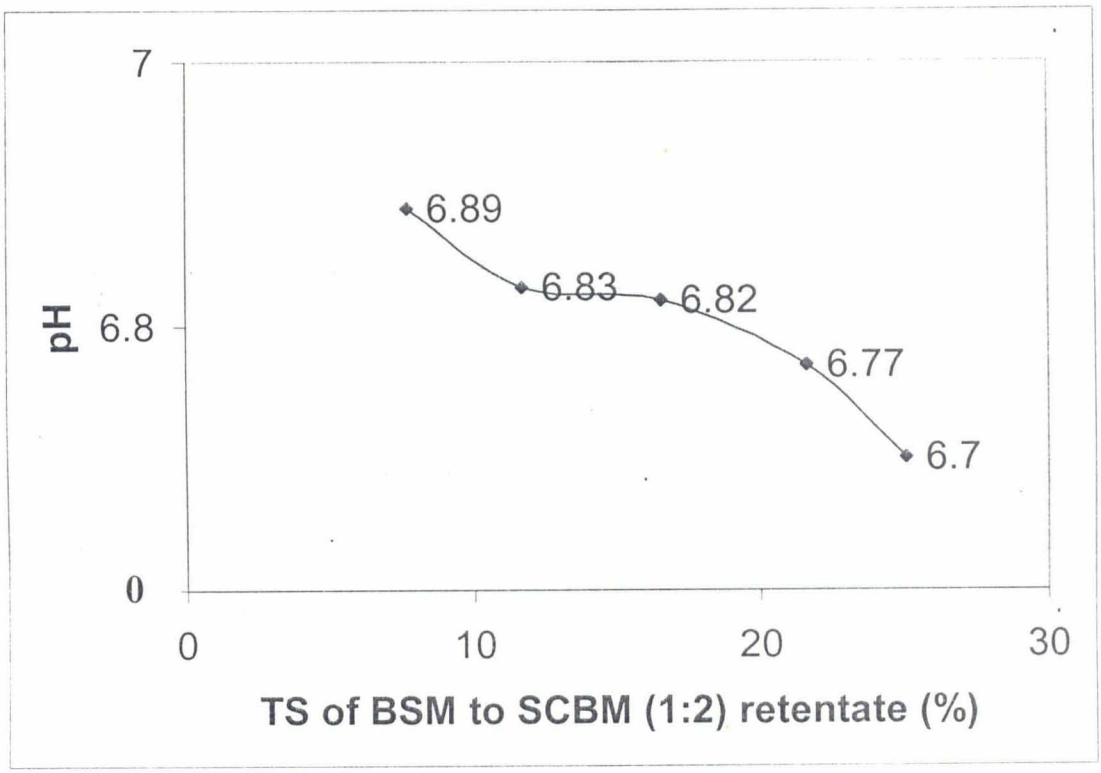

Fig. 4.13. Effect of UF concentration on pH of BSM added SCBM retentates (1:2)

4.2.14. Effect of different stabilizers on pH and heat stability of UF retentate (4.56-fold) made from BSM added SCBM (1:2)

The effect of different stabilizers namely Trisodium citrate, mixture of Monosodium phosphate and Disodium phosphate (2:1) and Dipotassium hydrogen phosphate are shown in Fig.4.14 and Fig.4.15. All stabilizers investigated in this trial, it has been observed that only Dipotassium hydrogen phosphate improved the heat stability of buffalo skim milk added SCBM (1:2) UF retentate at pH 7.15-7.35 and level of 0.5-0.7%, where as trisodium phosphate and mixture of Monosodium phosphate and Disodium phosphate (2:1) decreased the heat stability of the same.

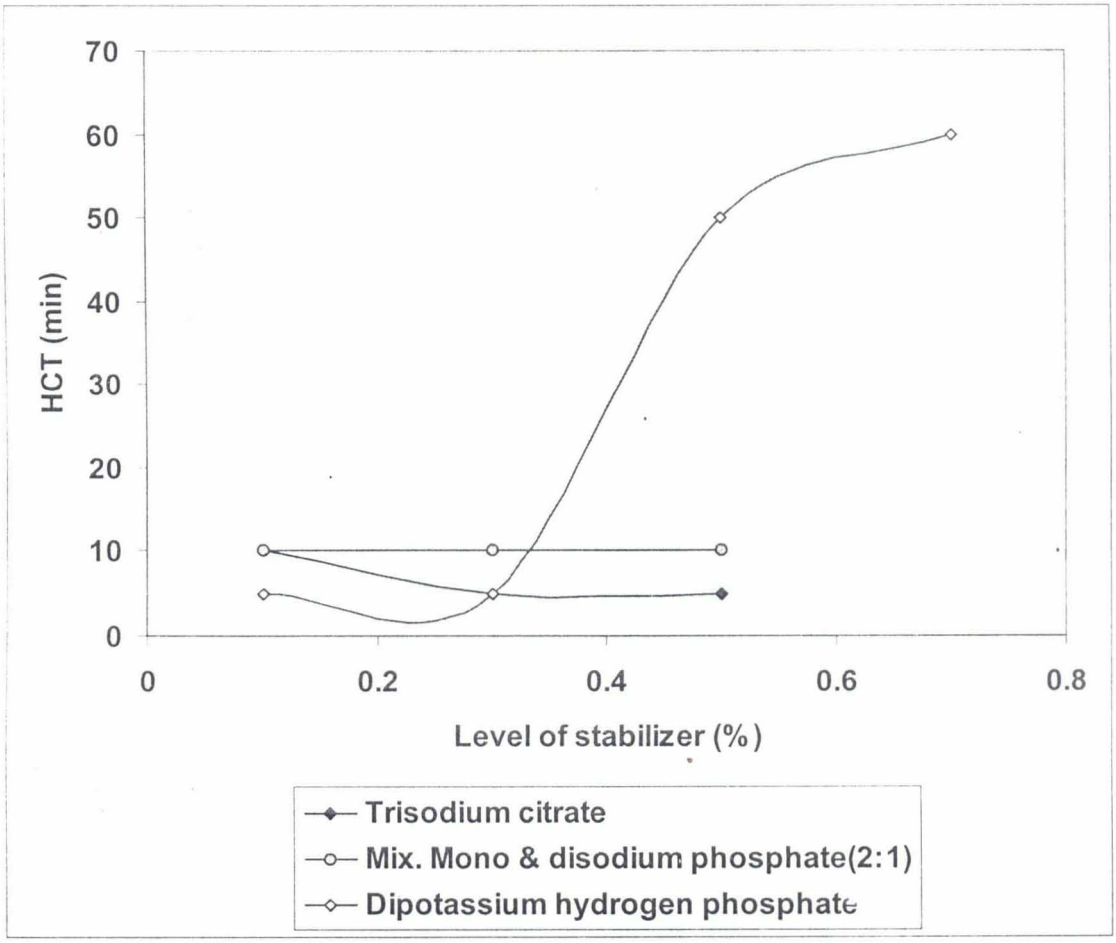

Fig. 4.14. Effect of different stabilizers on heat stability of BSM added SCBM (1:2) UF retentate

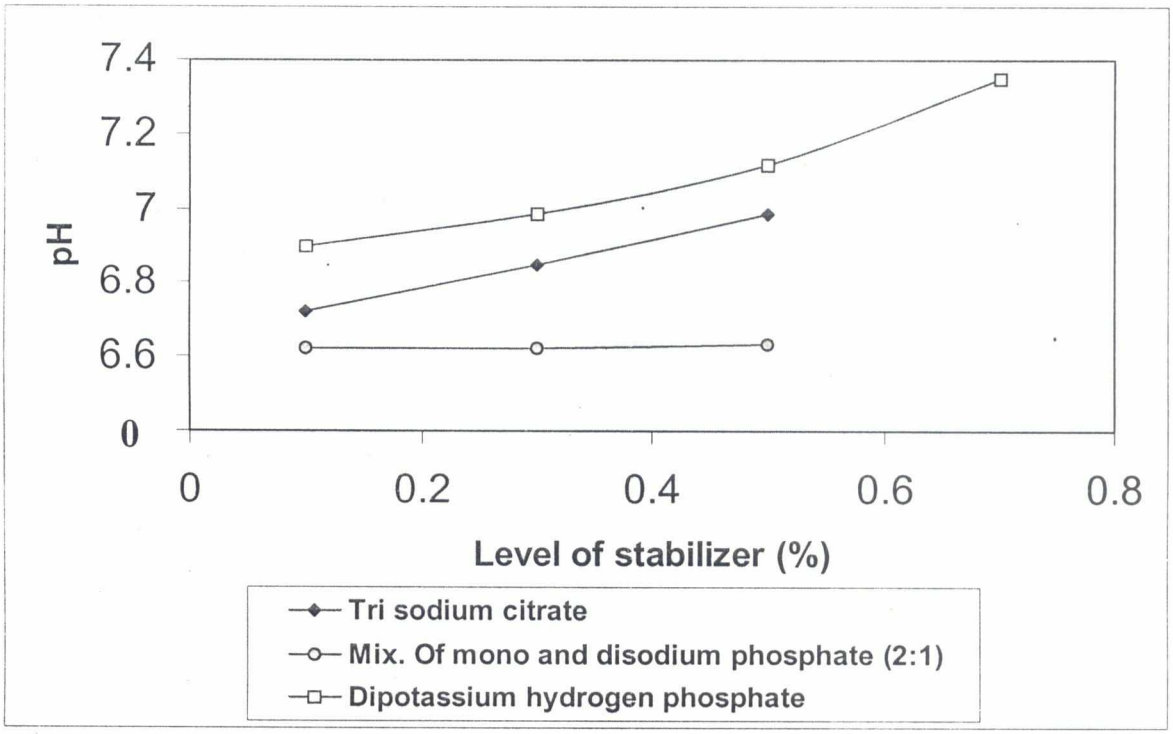

Fig 4.15. Effect of different stabilizers on PH of BSM added SCBM (1:2) UF retentate

4.2.15. Effect of sugar and stabilizer on the heat stability and pH of BSM added SCBM (1:2) UF retentate

The effect of sugar on pH and heat stability of BSM added SCBM (1:2 on total solid basis) UF retentate are shown in Fig. 4.16 and Fig. 4.17. It is evident from the Fig.4.16 that when sugar is added in 2.12, 3.20 and 4.56- fold, the heat stability decreased from 185 min to 115 min, 60 min to 40 min and 10 min to 6 min, respectively. The pH of UF retentate of 2.12, 3.20 and 4.56- folds decreased from 6.83 to 6.80, 6.82 to 6.70 and 6.77 to 6.60 on addition of 18% sugar on TS basis in the retentate, respectively. Reduction in heat stability of UF retentate is due to decrease in pH, because pH of sugar is 5.3–5.50 in distill water. The pH of UF retentate of 2.12, 3.20 and 4.56- folds further increased from 6.80 to 7.15, 6.70 to7.11 and 6.60 to 7.04 on addition of 0.5% Dipotassium hydrogen phosphate and hence heat stability of 2.12, 3.20 and 4.56- folds of UF retentate increased from 115 min to 240 min, 40 min to 215 min and 6 min to 50 min. Hence, it is concluded that after addition of 18% sugar on solid basis in different folds of UF retentate made from admixing of

buffalo skim milk and sweet cream buttermilk in proportion (1:2) decreased heat stability and on addition of 0.5% of Dipotassium hydrogen phosphate further improved the heat stability.

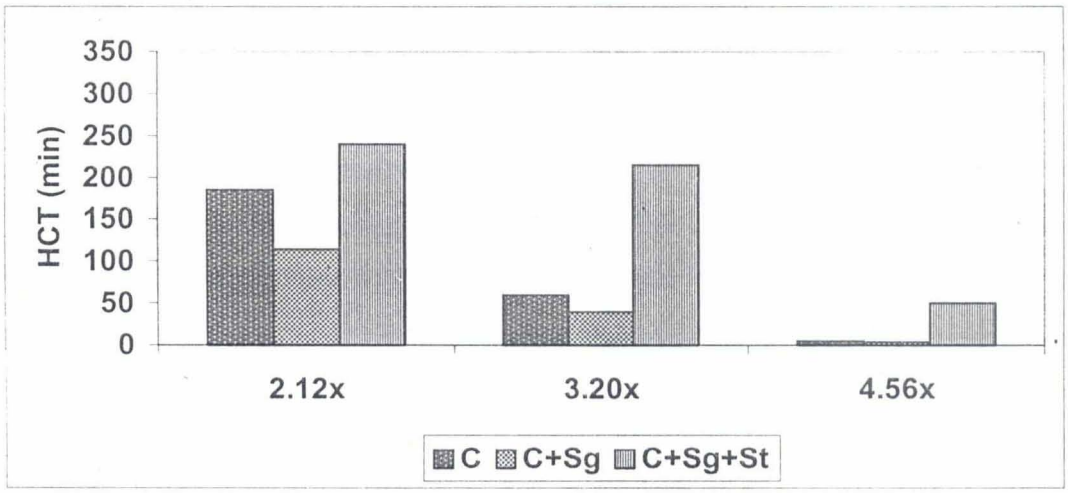

Fig. 4.16. Effect of sugar and stabilizer on the heat stability of BSM added SCBM (1:2) UF retentates

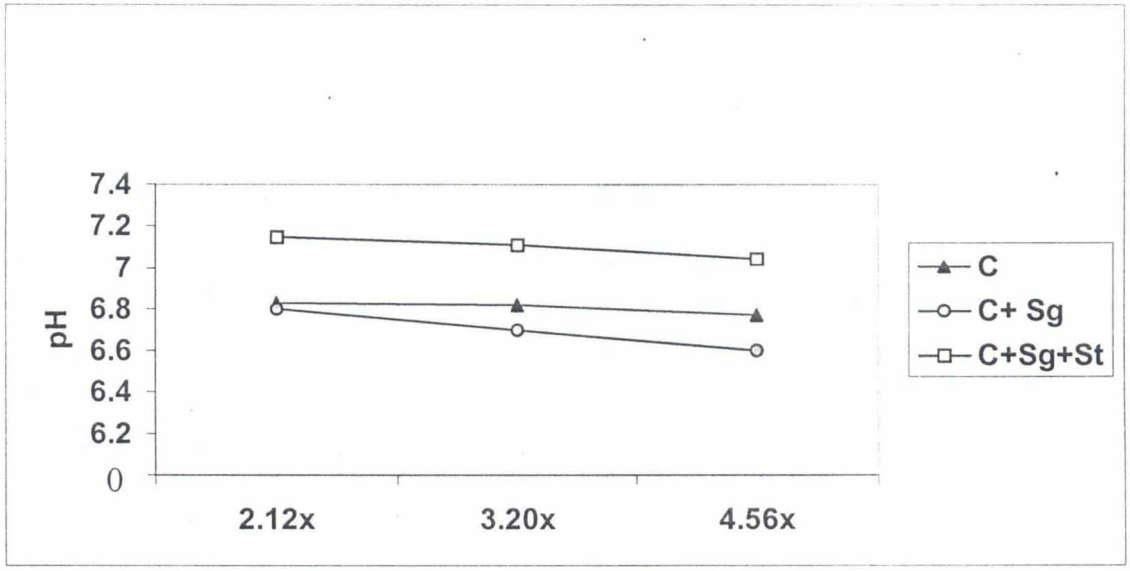

Fig. 4.17. Effect of sugar and stabilizer on pH of BSM added SCBM (1:2) UF retentates

4.2.16. Flavor improvement in BSM added SCBM (1:2) UF retentate

The improvement in flavor score of retentate (4.56-fold) obtained after admixing of BSM and SCBM in proportion (1:2) was tried. During ultrafiltration the loss of minerals and the large reduction in lactose content takes place. So, KCl was added to the retentate at the @ 0.2 %. A control sample of the retentate without the addition of KCl was also made. All these samples were evaluated for flavor. The score obtained for flavor shows that addition of salt do not improve flavor rather it decreased the sensory score for flavor.

Table 4.5. Effect of addition of KCl on flavor score of BSM added SCBM (1:2) UF retentate (4.56-fold)

Parameter	Amount of KCl added (%)	
Flavor	0	0.20
	7.4	6.4

4.2.17. Sensory score of different concentration of BSM added SCBM (1:2) UF retentates in Tea

The different concentration of BSM added SCBM (1:2) UF retentates were evaluated for sensory parameters in tea are shown in Fig. 4.18. The flavor scores for different total solid level are 7.57, 7.88, 7.61 and 7.42 for TS 11.72, 16.58, 21.60 and 25.04%, respectively. The overall acceptability scores are 7.41, 7.79, 7.74 and 7.39 for TS 11.72, 16.58, 21.60 and 25.04%, respectively. The overall acceptability score 7.79 and 7.74 are almost similar. Thus, it is concluded that concentration level TS (16.58%) to TS (21.04%) selected for formulation of liquid non-fat dairy whitener.

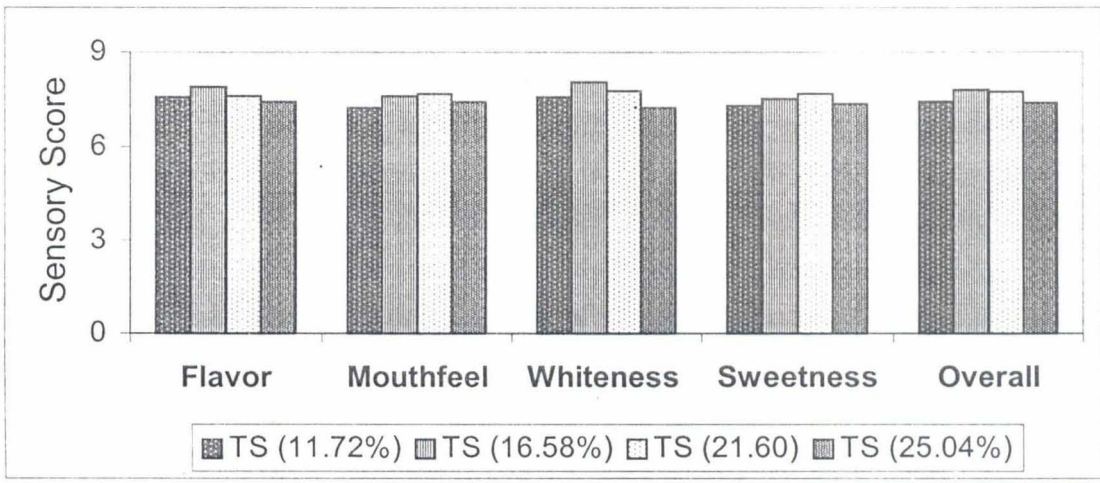

Fig. 4.18. Sensory score of different UF concentration of retentates made from admixing BSM to SCBM (1:2) in Tea

Table 4.6 ANOVA – Sensory scores for flavour, mouthfeel, whitening, and appearance of non-fat dairy whitener in Tea

Source of Variation	D.F	Flavour		Mouthfeel		whitening Ability		Appearance	
		M.S.S	F	M.S.S	F	M.S.S	F	M.S.S	F
Products	3	0.214	1.085	0.238	1.558	0.702	2.980*	0.588	3.463
Judges	6	0.674	3.415**	0.688	4.50**	0.080	0.341	0.426	2.507*
Replicate	1	0.286	1.447	0.286	1.87	0.161	0.682	0.004	.0260
Error	45	0.197		0.153		0.236		0.170	
Total	55								

** Significant at 1% level * Significant at 5% level

4.2.18. Whitening ability

The whitening ability of different concentration of BSM added SCBM (1:2) UF retentates in tea/coffee are shown in Fig. 4.19 & Fig. 4.20. The color parameter of different concentration of BSM added SCBM (1:2) UF retentate were measured by Tristimulus Spectrophotometer Hunter Lab model Color Flex® (Hunter Associates Laboratory Inc., VA, U.S.A.). Color was recorded using the CIE-L^* a^* b^* uniform color space (CIE-Lab), where, L^* indicates lightness, a^* indicates hue on a green (-) to red (+) axis, and b^* indicates hue on a blue (-) to yellow (+) axis. The L* value of the L* a* b * color system proved to be the most useful parameter for the characterization of whitening ability. The L* a* b* value in tea are 47.53, 10.24 and 26.44 for 2.12- fold, 50.24, 10.15 and 26.16 for 3.20- fold, 50.91, 9.91 and 26.01 for 4.56- fold. The L* a* b* value in coffee are 54.03, 5.68 and 21.69 for 2.12- fold, 54.61, 5.46 and 20.86 for 3.20-fold, 57.69, 5.37 and 21.17 for 4.56- fold, respectively having same total solid (3%). The L* value of 4.56-fold (50.91) in tea is marginally higher than 3.20- fold (50.24) but in coffee the L* value of 4.56- fold (57.69) is significantly higher then 3.20-fold (54.61). Therefore, it can be concluded that 4.56- fold having TS 21.60% is suitable for final formulation of non- fat liquid dairy whitener due to better whitening ability. All samples have significant difference in colour value. The selected 4.56-fold sample was pasteurized at 85°C/5 min with addition of 0.5% Dipotassium hydrogen phosphate and 18% sugar on TS basis in it. Finally cool to 4°C and stored at refrigeration temperature.

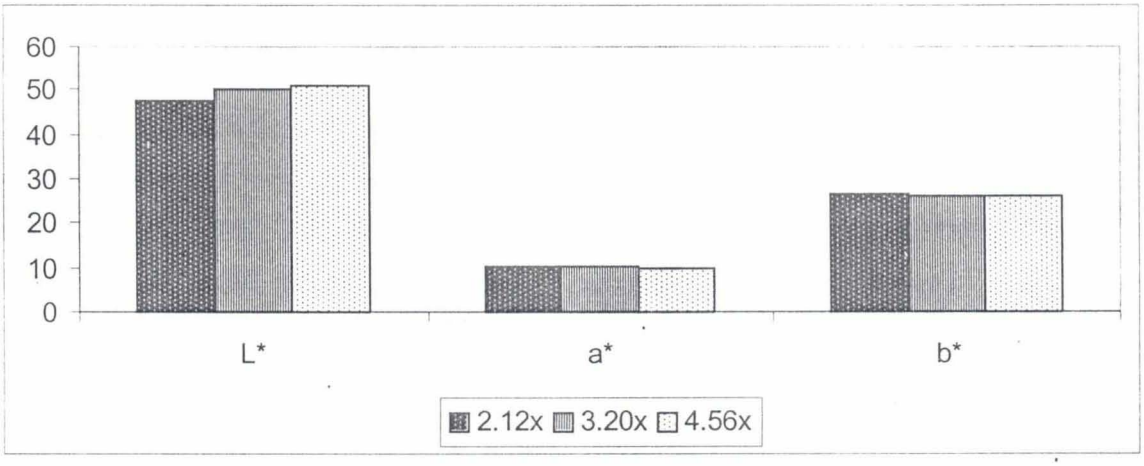

Fig. 4.19. Color parameters of BSM added SCBM (1:2) UF retentates in Tea.

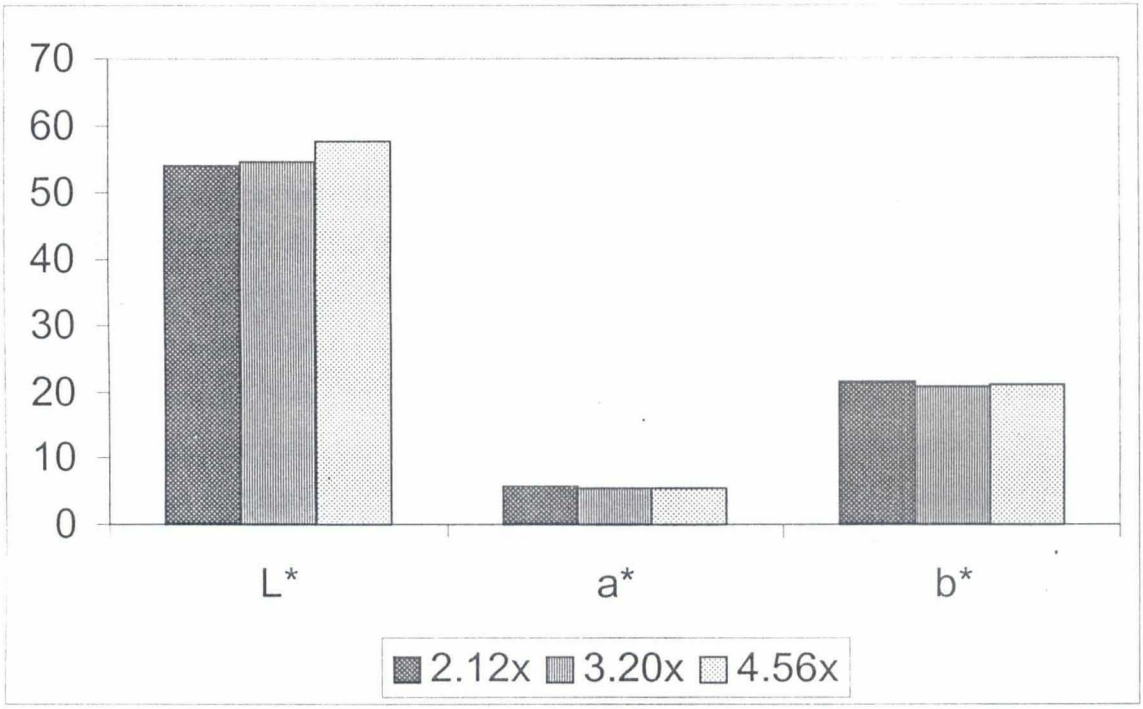

Fig. 4.20. Color parameters of BSM added SCBM (1:2) UF retentates in Coffee.

Table 4.7 ANOVA –Colour parameter of non – fat Dairy Whitener samples in coffee on CIE- L* a* b*

Source of Variation	D.F	L*value		a*value		b* value	
		M.S.S	F value	M.S.S	F \value	M.S.S	F value
Samples	3	7.107	7788.28**	0 .068	1494.09**	0.264	720.27** -
Replicate	1	0.003	3.082	0.002	46.091**	0.001	2.182
Error	3	0.001		0.00		0.00	
Total	7						

** Significant at 1% level

4.3. Formulated non-fat Dairy Whitener and Market sample

4.3.1. Whitening ability

The whitening ability of non-fat liquid dairy whitener and Market sample in tea/coffee are shown in Fig. 4.21 & Fig. 4.22. The L* a* b* value in tea are 50.91, 9.91, 26.01 for liquid non- fat dairy whitener and 45.83, 11.55, 26.67 for market sample having same total solid (3%). The L* value indicates that liquid non-fat dairy whitener having more whitening ability than market sample. The L*a*b* value for non-fat liquid dairy whitener in coffee are 57.69, 5.37, 21.17 and for market sample 49.92, 7.00, 22.18 having same total solid (3%). The L* value indicates that liquid non-fat dairy whitener having more whitening ability than market sample may be due to high protein. When we compare whitening in tea and coffee having same total solids than it was observed that liquid non-fat dairy whitener having more whitening in coffee than tea, may be due to high protein content.

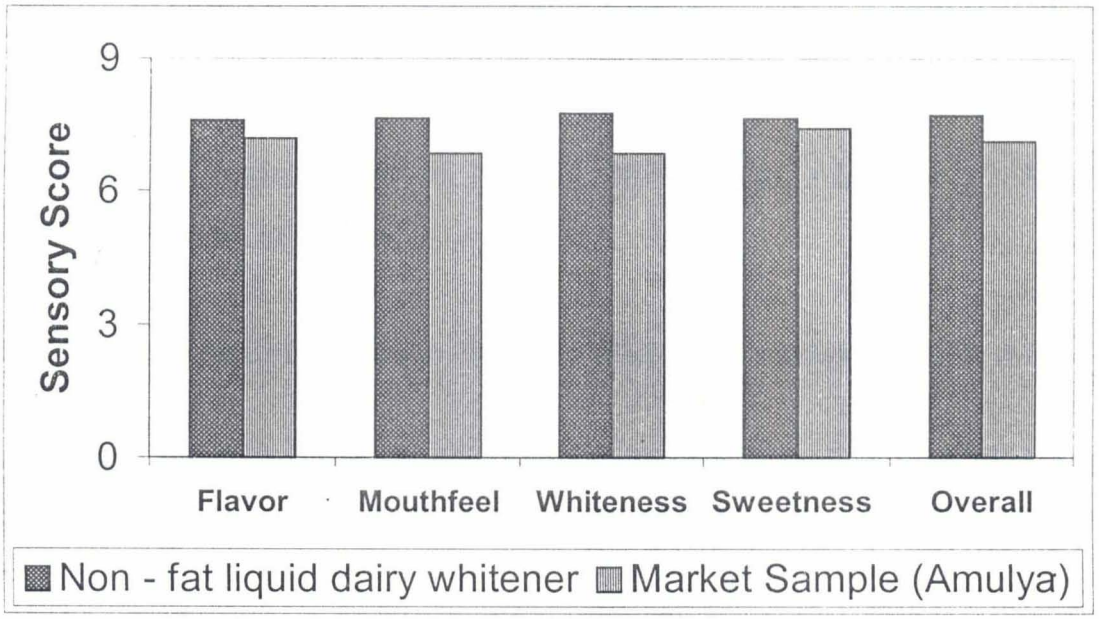

Fig. 4.21. Whitening score of Non-fat liquid Dairy Whitener v/s Market sample in Tea

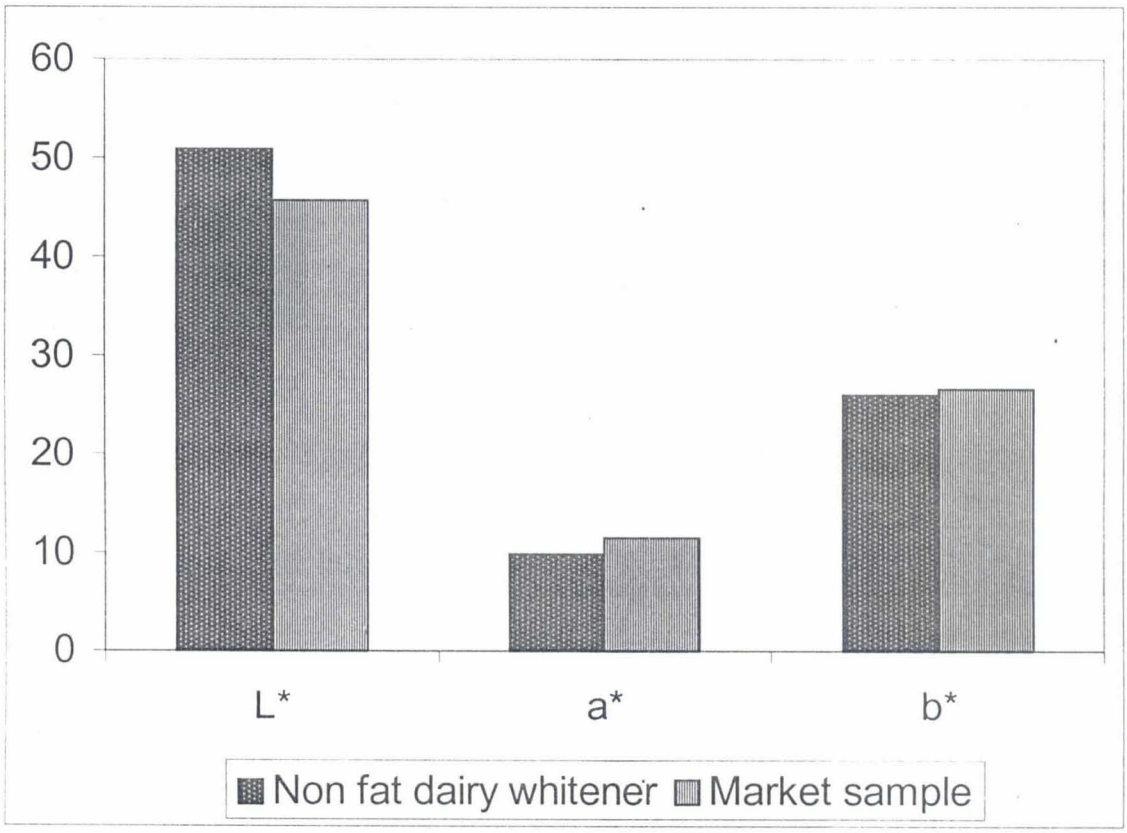

Fig 4.22. Whitening score of Non-fat liquid dairy whitener v/s Market sample in Coffee

4.3.2. Sensory score of liquid non-fat Dairy Whitener v/s Market sample in Tea

The sensory evaluation of formulated non-fat dairy whitener and market sample (Amulya) were done by a panel of judges on 9-point Hedonic scale in tea/coffee. The flavor, mouthfeel, whiteness, appearance and overall acceptability of formulated non-fat dairy whitener sample was significantly ($p<0.01$) higher than market sample except sweetness because SCBM acts as refreshing agent having higher amount of lipoprotein membrane imparts creamery mouthfeel.

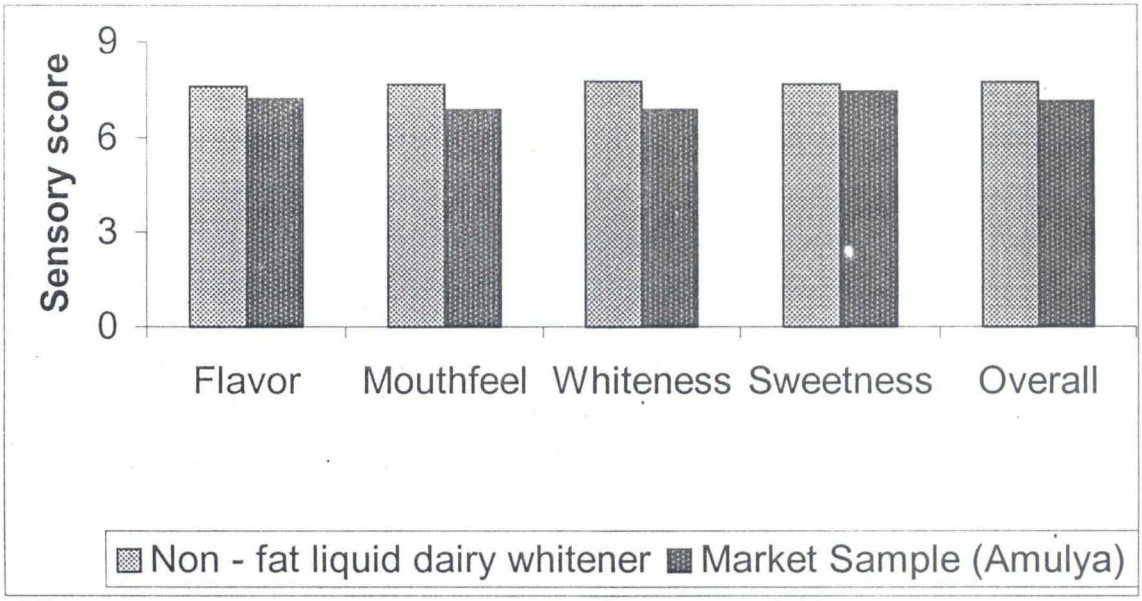

Fig. 4.23. Sensory score of liquid non-fat Dairy Whitener and Market sample in Tea

Table 4.8. ANOVA – Sensory scores for flavour, mouthfeel, whitening, and appearance of non-fat Dairy Whitener and Market sample in Tea

Source of	D.F	Flavour		Mouthfeel		whitening Ability		Appearance	
Variation		M.S.S	F value	M.S.S	F value	M.S.S	F value	M.S.S	F value
Sample	1	2.286	9.61**	3.571	14.55**	5.143	24.64**	2.286	8.81**
Judges	6	0.414	1.74	0.473	1.92	0.560	2.68	0.310	1.19
Replicate	1	0. 321	1.35	0.143	0 .582	0.143	0.685	0 .036	0.138
Error	19	0.238		0.245		0.209		0.259	
Total	27								

** Significant at 1% level

4.3.3. Gross chemical composition of formulated non- fat liquid Dairy Whitener

The gross chemical composition of non- fat liquid dairy whitener using ultrafiltration SCBM as a base material is given in Table 4.6. The composition of final formulated non-fat dairy whitener was TS- 25.98%, Fat-0.8%, Protein-16.68%, Lactose-2.75%, Ash-1.92%, Sucrose 3.88%, Stabilizer 0.5% and Calcium -1123.06 mg/kg). This standardized formulation scored significantly ($p<0.01$) higher on sensory score & colour parameters in tea/coffee than market sampie.

Table 4.9. Composition of liquid non-fat Dairy Whitener formulated in this project

Characteristics	Percentage
Total solid	25.98
Fat	0.80
Protein	16.68
Lactose	2.20
Sucrose	3.88
Ash	1.92
Stabilizer	0.50
Calcium (mg/Kg)	1123.06

5. Summary and Conclusions

Dairy whiteners are widely used in tea/coffee to whiten the beverage. The formulation of non-fat dairy whiteners using ultrafiltered sweet cream buttermilk as base has many advantages like reduction in product cost, process simplification and enhanced nutritive value due to inclusion of whey protein in the product. In India, Dairy plants having condensing and drying units are mostly diversifying to the production of dairy whiteners. Buttermilk could be mixed with buffalo skim milk for conversion to non-fat dairy whiteners. However, no study on suitability of buttermilk for use as a dairy whitener has yet been reported. At present only (8-10%) of total buttermilk are utilized in spray drying with skim milk and a considerable amount of buttermilk in our country is still drained. Proper utilization of buttermilk, particularly in this value added product, would not only conserve the valuable nutrients, but also minimize dairy effluent disposal problem. The present investigation was, therefore, undertaken to standardize the formulation of non-fat dairy whitener using ultrafiltered SCBM as a base and also study its physico-chemical and sensory properties as such and in tea/coffee. The results obtained during the present investigation are summarized and concluded in this chapter.

Sweet cream buttermilk was concentrated by pilot ultrafiltration plant upto 5.20-fold concentration. The flavor of SCBM UF retentates (1.76-fold, 2.87-fold, 4.04-fold, and 5.20-fold) was evaluated by a panel of judges. 5.20-fold UF SCBM retentate scored low (5.25 on 9-point Hedonic scale) on flavor evaluation as such. For improving its flavor, buffalo skim milk UF retentate was mixed in different proportion to SCBM UF retentate. The skim milk UF retentate added buttermilk UF retentate in the proportion of 1:2, on total solid basis, scored better (6.5) for flavor. Though skim milk UF retentate added buttermilk UF retentate in the proportion of 2:1, on total solid basis, scored maximum (7.0) for flavor, 1:2 proportion of skim milk UF retentate added buttermilk UF retentate was selected for further studies as this proportion helped in maximum utilization of buttermilk in the formulation of dairy whitener. This mixture scored 7.5 for flavor in tea sample, mostly due to the masking effect of tea.

Heat stability of buttermilk UF retentates was observed to decrease with the increase of UF concentration. An investigation was carried out to improve the heat stability of 5.20-fold

UF buttermilk retentate by adding different stabilizers, namely trisodium citrate, mixture of mono & disodium phosphate (2:1 w/w) and dipotassium hydrogen phosphate at different levels. The addition of trisodium citrate to SCBM retentate rather decreased the heat stability tremendously. The addition of monosodium and disodium phosphate mixture (2:1 w/w) and dipotassium hydrogen phosphate to SCBM retentate showed significant increase in its heat stability. Addition of 0.5 % dipotassium hydrogen phosphate increased the heat stability of SCBM UF retentate from 40 min to120 min and was observed to be most effective.

Heat stability of buffalo skim milk added SCBM (1:2, on total solid basis) UF retentate was also investigated. It was observed that as the UF concentration increased, the heat stability of the UF retentate decreased. The heat stability of 5.8 UF fold retentate was observed to be 10 min. The improvement in its heat stability was investigated with the addition of stabilizing salts. The addition of trisodium citrate to UF retentate tremendously decreased the heat stability. The addition of monosodium and disodium phosphate mixture (2:1w/w) did not improve the heat stability of UF retentate. Only dipotassium hydrogen phosphate was observed to be effective (0.5% being optimum) in improving the heat stability from 10 min to 50 min.

Addition of 18% sugar, on total solid basis, to the optimized buffalo skim milk added SCBM (1:2, on total solid basis) UF retentate decreased the pH and heat stability, but addition of 0.5% dipotassium hydrogen phosphate improved its heat stability.

Based on the above mentioned observations, non-fat dairy whitener was formulated with the buffalo skim milk added SCBM UF retentates by adding 0.5% dipotassium hydrogen phosphate and 18% sugar, on total solid basis, and heat treated at 85^{o}C for 5 min. The formulated non-fat dairy whitener prepared with 3.20 and 4.56 fold UF retentate scored better in flavor (7.78, 7.07) than other samples. When different folds of buffalo skim milk added SCBM (1:2, on total solid basis) UF retentate were evaluated in tea sample having same total solid (3%), the flavor score (7.88, 7.61) were better due to masking effect of tea and it was observed that flavor and overall acceptability of 3.20- and 4.56-fold UF retentate in tea was almost equal. Whitening ability in terms of L* value of formulated non-fat dairy whitener prepared with 4.56-fold UF

retentate in tea was observed to be better (50.91) than 50.24 of formulated non-fat dairy whitener prepared with 3.20 fold.

On the basis of sensory, heat stability, color parameters and economy point of view, 4.56 fold UF retentate was observed to yield optimum quality of formulated non-fat dairy whitener. The composition of final formulated non-fat dairy whitener was TS- 25 .98%, Fat-0.8%, Protein-16.13%, Lactose-2.75%, Ash-1.92%, Sucrose 3.88%, Stabilizer 0.5% and Calcium -1123.06 mg/kg). This standardized formulation scored significantly ($p<0.01$) higher on sensory attributes and imparted greater whiteness in tea/coffee than did market sample of dairy whitener.

Flow chart for formulated non-fat liquid Dairy Whitener

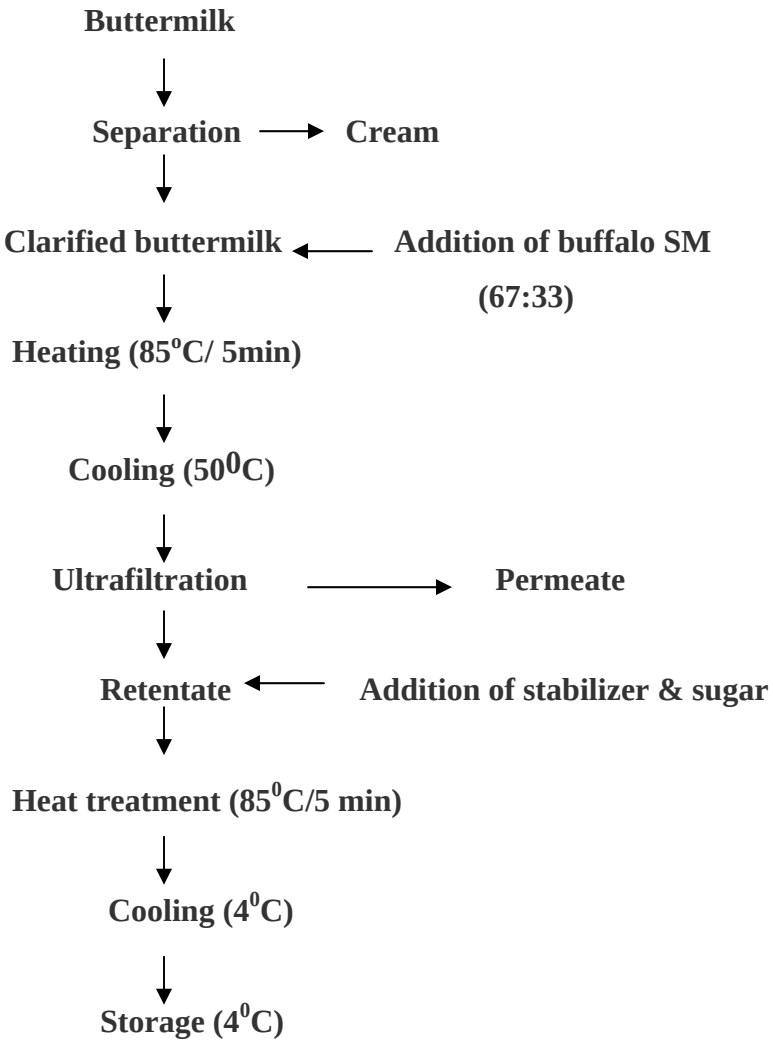

Fig. 5.1 Flow chart for formulation of non-fat Dairy Whitener

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